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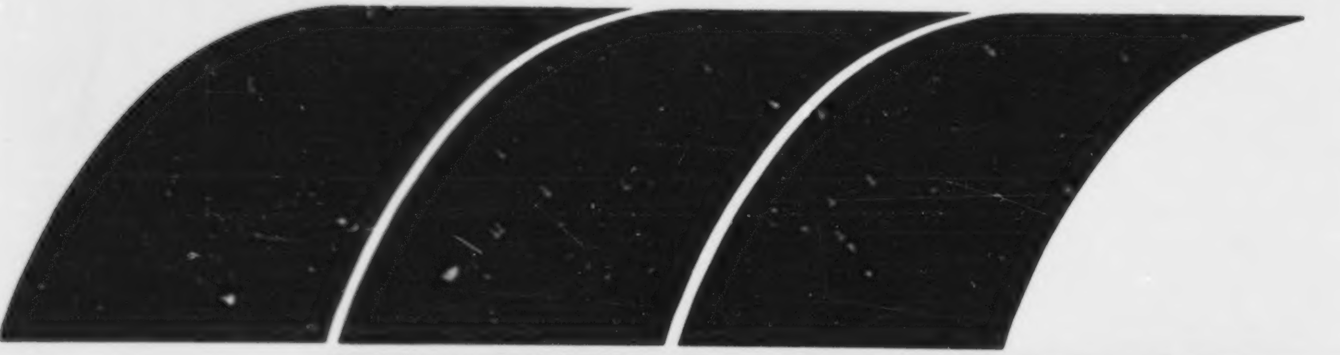

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by

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ABSTRACT

The threat of oil pollution in the Strait of Juan de Fuca has prompted this study of marine birds in Washington State. The study was conducted from 1 January 1978 to 31 December 1979 in the Strait of Juan de Fuca north to the San Juan Islands and Point Roberts and west to Sidney, British Columbia. Major objectives were to determine the time of occurrence, distribution, abundance, and locations of important concentrations of marine birds. Bird census methods included: (1) point census, (2) sea watch, (3) beach census, (4) dead bird census, (5) small boat census, (6) ferry census, and (7) aircraft census. Data were obtained on breeding marine birds on 99 geographic units in American waters.

All field data were coded according to NOAA/NODC-approved codes and formats. Keypunched data were read onto a disk file and later transferred to a storage tape. After errors were corrected, two cross-reference programs were run to arrange data into appropriate order for later analysis. During the two-year survey period, data were generated on five record types. Computer output included total birds observed, standard deviation, number of censuses, weighted density, projected total numbers, percent of projected total numbers (for each species), biomass, percent of projected total biomass, and bird oil index.

The study area was divided into 13 regions and 64 subregions. Where appropriate, open water and shoreline habitats were treated separately since they differ biologically.

During this two-year study 116 species of marine birds were observed. Maximum species richness occurred in the fall with 105 species observed. Species richness at other seasons was 84 species for spring, 71 for summer, and 91 for winter.

There were approximately 34,300 nesting pairs of 12 species found nesting in the U.S. area. An additional 5,000 pairs were found nesting in adjacent Canadian area. The most important colony sites were Protection Island (22,000 pairs), Tatoosh Island (3,800 pairs), Colville Island (1,200 pairs), and Smith and Minor Islands (850 pairs). The most abundant species were the Rhinoceros Auklet (17,900 pairs) and the Glaucous-winged Gull (11,000 pairs).

Seasonal distribution, abundance and species composition are discussed according to foraging and roosting habitats and by region. Important vulnerable species are discussed in detail. The numbers and species composition of marine birds varied seasonally. Projected total populations for the entire study area were spring 360,000-405,000 birds, summer 38,000-84,000, fall 486,000-550,000, and winter 670,000. Large annual variations in numbers are

apparently characteristic of the populations inhabiting the study area. Annual changes in numbers from 10-250% are common in some subregions. Locations where birds concentrate, however, are consistent and predictable. Highest seasonal densities occurred in shallow bays and estuaries where values ranged from 600-1,500 birds/km^2. At the same time densities over open waters ranged from 2-72 km^2. Fronts or "convergences" provided a rich source of food and thereby attracted larger numbers of birds. The spring herring spawn attracted very large numbers of birds (25,000), especially scoters, in a few areas. The types, abundance, and location of roost sites were studied and considered to be important to the survival of several species.

Mortality rates of marine birds in the study area were low and ranged from 0.17 to 0.28 dead birds/km/census. The incidence of oiling during 1978 and 1979 was also very low.

Species most vulnerable to oil pollution are those that dive beneath the water and those that spend nearly all their lives on the water. Those species include the loons, grebes, cormorants, diving ducks, and alcids.

The subregions of the study area were assigned seasonal rankings by using a Bird Oil Index (BOI) and BOI/km^2. The BOI was developed as an index of the various aspects of behavior, biology, and distribution and abundance as related to exposure to oil on the water surface. The most critical areas, called "Significantly Important Areas," are: Tatoosh Island; open waters of the Strait of Juan de Fuca; Jamestown; Protection Island; Admiralty Inlet; Smith Island; rocks and islands on the south shore of Lopez Island; southern San Juan Channel; Rosario Strait; Padilla Bay; Samish Bay; Bellingham Bay; Lummi Bay; Cherry Point; Boundary Bay, B.C.; Roberts and Sturgeon Banks, B.C.; Active Pass, B.C.; Mandarte Island, B.C.; Skagit and Port Susan Bays; and Penn Cove and Crescent Harbor area.

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I. INTRODUCTION

A. General Background

The Puget Sound region is one of the major habitats for marine birds on the Pacific Coast of North America. The shoreline, estuarine, and open water environments support a wide variety and large populations of bird species. These environments provide important summer nesting habitats to many species; they provide one of the most important wintering areas in the eastern Pacific; and they represent a crucial link in coastal habitats for birds migrating along the Pacific Coast.

B. Previous Avifaunal Studies in the Region

Prior to 1978, few intensive studies of marine birds had been conducted in the region. Early observations are partially summarized in Dawson and Bowles (1909) and Jewett et al. (1953). Numerous short notes on the distribution of marine birds are published in the Murrelet, in Audubon Field Notes (now American Birds) or as in Bakus (1966). Surveys and catalogs of Washington and British Columbia include Drent and Guiget (1961), Drent et al. (1964), Peters et al. (1978), Manuwal (1977), Manuwal and Campbell (1979), and Campbell (1979). A bibliography of Washington State birds was prepared by Alcorn (1972). A recent checklist of the birds of Washington State was prepared by Mattocks et al. (1976). With the exception of unpublished waterfowl surveys conducted by the Washington Department of Game and the U.S. Fish and Wildlife Service, no intensive studies on the distribution and abundance of marine birds in the Strait of Juan de Fuca-northern Puget Sound have been conducted. The results of the first year of this distributional study of marine birds of the Strait of Juan de Fuca-northern Puget Sound are reported in Manuwal et al. (1979).

There have been several studies on the breeding biology of some species. Most research in northern Washington and British Columbia waters has been done on the Glaucous-winged Gull. These studies include those by Schultz (unpublished), Vermeer (1963), Ward (1973), Stout et al. (1969), Stout and Brass (1969), Thoreson and Galusha (1971), and Galusha and Stout (1977). Research on the Black Oystercatcher was done primarily by Hartwick (1973) in British Columbia and Nysewander (1977) in Washington. Cormorants have been studied by Van Tets (1959, 1965) in British Columbia; no studies have been conducted in Washington. Pigeon Guillemots have been intensively studied by Thoresen and Booth (1958) in Washington and by Drent (1965) in British Columbia. Rhinoceros Auklets were first intensively studied by Richardson (1961) on Protection Island. Populations and biology were studied on Destruction Island (Leschner 1976), Protection Island (Wilson 1977), and Smith Island (Manuwal unpublished) in Washington. Summers and Drent (1979) investigated a colony on Cleland Island, British Columbia.

C. Effect of Human Activities on Marine Birds

Bird populations have long been influenced by various human activities within the study area. Early inhabitants utilized many species for food, used seabird colonies as sources of eggs, and used Tatoosh Island as a fishing/whaling camp. Subsequently, increasing human populations have resulted in disruption of food resources, disruption of colony sites, reduction of available habitat, and increased mortality for various marine birds. Food resources have been affected by industrial thermal and chemical discharges, by human garbage and sewage disposal, and by direct competition for prey species (e.g., herring). Colony site locations have been used for lighthouses, for bombing targets, and by recreationists, as well as being disturbed by vessel traffic. Available habitat has been reduced by dredge-and-fill and diking operations and by housing developments. Log-booms have, however, provided roosting habitat for a number of species. Mortality losses increased due to increased hunting pressure over a diminished habitat area, to predator "control" shooting programs of several fish-eating species, and to losses in fish nets.

Effects of human activities have resulted in increases in some species (gulls), whereas others have decreased (puffins). As a whole, human impacts have been negative. For various reasons, some of these practices have been stopped, some have more or less stabilized, and several are expanding and intensifying. Many of these will be apparent in the following sections.

Unlike the situation in many other populated regions, the effects of many of these changes in the natural system, while intensive, have been localized. While virtually every part of the study area has been touched by human populations or their effluents, there are extensive areas which remain very important to populations of marine birds and mammals.

D. Effects of Oil Pollution on Marine Birds

Oil pollution is now a well-known threat to marine birds (see Bourne 1968, and Vermeer and Vermeer 1975). Thus far, however, there has been little impact on the marine birds of Washington resulting from the production, handling, and transportation of crude oil. Increased oil tanker traffic in the Strait of Juan de Fuca and northern Puget Sound in recent years results from higher consumption of oil products in the United States and Canada, loss of supply of Canadian crude oil via the overland pipeline, and the necessity for refining Alaskan crude oil. This, in turn, has resulted in proposals for establishment of additional oil terminal facilities and transhipment lines in the area.

As the result of several oil spills around the world, and research stimulated by these oil spills on the effects of oil on marine organisms, it is now possible to begin to identify the ways in which oil affects marine birds. These effects of oil pollution on marine birds are best considered through their actions on both nonbreeding birds and on breeding birds, their eggs, and their young. Effects on adult birds during the breeding season are similar to those during the nonbreeding season; they are also similar to nonbreeding birds (see Holmes and Cronshaw 1977).

A small amount of oil on the plumage of a bird is sufficient to cause stress and often death. The most obvious effect of oil on a bird is the matting of the plumage and the loss of the thermal layer it provides, resulting in unacceptable heat loss (Holmes and Cronshaw 1977). Extensive oiling can also result in the loss of buoyancy often resulting in drowning. The combination of heat loss and the physical activity of trying to stay afloat can be fatal. This is compounded by the bird's probable inability to continue to forage at a rate to offset these losses of energy. Many species, particularly puffins, murres, and auklets, are highly specialized underwater predators, literally chasing down fish and other mobile prey items. Impairment of this ability would be detrimental to the bird's survival. Predator avoidance and the ability to respond to unfavorable environmental conditions (such as a storm and the rough seas that accompany it) are other factors related to the possible loss or impairment of flight.

Physiological exposure to oil occurs in two ways. The first is external, with the oil matting the feathers and reaching the skin of the bird where various fractions of oil are differentially absorbed. The second is through the ingestion of oil during feeding or preening and thus establishes direct contact with internal organs of the bird. Within the digestive tract oil fractions are differentially absorbed.

Breeding birds are affected in all the above ways, but during the breeding cycle other effects of oil can occur. One such effect is through disruption of egg laying. Some species that have been tested show that after ingesting oil, they lose the ability to lay eggs, at least for a short period of time. If eggs are produced, the contamination of the surface of eggs with very small amounts of oil can cause drastic reductions in hatching success (Bourne 1968). In such cases, the embryo is killed during early stages of development. Later in the nesting cycle, the ingestion of oil by nestlings can lead to abnormal growth of essential organs.

Oil reaches the nest in three ways. The first is through oil on the feathers of the adult coming in contact with the egg(s) or the chick(s). It is not uncommon to see adult birds with oil spots on their plumage. The second manner in which oil can reach the nest is through its contamination of nesting material gathered by the adults and brought to the nest site for nest construction. The third route of oil to the nest site is in and on foods that the adult birds bring back to feed to their young. Oil removed from adult feathers could also appear on food for the nestlings.

Species are not equally vulnerable to oil. For example, diving birds which spend their entire nonbreeding life on the water are more vulnerable than gulls, and a bay populated largely by diving birds such as grebes is more vulnerable than a bay populated largely by gulls. Additionally, the population of any species present in the study area represents a given portion of that species' total North American population. Thus, the larger the portion that is present here the more important it is to the species' total population. Further, some species are represented by a larger total population than others. Some species have a greater reproductive potential than others and can theoretically recover population losses more quickly than other species.

In Washington there are only two published accounts of seabird mortality associated with oil contamination. The spill from the wreck of the freighter Seagate on the outer coast of Washington on 6 September 1956 resulted in the loss of White-winged Scoters and Common Murres. Perhaps 3,000 birds of these two species were lost, but surveys were incomplete and it is not known what proportion of the affected birds actually reached shore (Richardson 1956). These two species, as well as others, also occurred in samples of dead birds found in March 1976 on the outer coast of Washington (Harrington-Tweit 1979). The source of the oil is unknown, but most of the four most commonly killed species were oiled: Northern Fulmar (43% oiled), Black-legged Kittiwake (66%), Common Murre (95%), and White-winged Scoter (90%).

In other spills, we feel it is significant that 92% of the birds received at cleaning and receiving stations during the San Francisco oil spill of 18 January 1971 were grebes, scoters, and alcids out of a sample of 3,690 birds (Smail et al. 1972). During the Santa Barbara oil spill, numbers of Western Grebes were oiled (pers. obs.). The Torrey Canyon disaster resulted in the loss of numbers of birds, and of a large sample 97% were guillemots (the same as our Common Murre) and Razorbills; both species are alcids (Bourne 1968). In the AMOCO Cadiz oil spill, a sample of birds from beaches revealed that 64% of the birds oiled were alcids; the Razorbill, murre, and puffin. One seabird colony on the coast of Brittany was severely affected by the Torrey Canyon oil spill, with drastic reductions in the breeding population. The AMOCO Cadiz oil spill apparently further reduced this seabird colony.

The total loss of birds to oil spills is difficult to calculate. This is partly due to the sinking or other losses of oiled birds before they reach the beaches. Hope-Jones et al. (1970) experimentally found that carcasses of large auks, such as murres, move at a rate of 2.2% of the wind velocity; larger species up to 3%. Their studies indicate that only about 20% of oiled carcasses reach beaches. In another study, Coulson et al. (1968) found that only 25% of shags that die from paralytic shellfish poisoning ever reach shore. More recent studies (Bibby and Lloyd 1977) also show that a small percentage of dead birds reach a shoreline. In the spills discussed above the loss has ranged from just a few thousand birds to tens of thousands of birds in one case. It is significant that the species involved in these spills--those species that are hardest hit and apparently most susceptible to oil spills--are in part the same species that occur in our study area--scoters, Common Murre, Western Grebe--or are closely related and share nearly identical ecological and behavioral characteristics--puffins, Razorbill, and grebes. The Rhinoceros Auklet is very similar in most attributes to the closely related Common Murre, the puffin, and the Razorbill. The species most vulnerable to oil spills are those that either live most of their lives on the water or those that dive to feed and to escape predation or disturbance.

E. Objectives of Study

Although birds are often the most obvious and dramatic casualties of oil spills, no adequate studies on avian distribution, abundance, and seasonal occurrence existed for the Puget Sound region. The importance of the area to marine birds, the imminent increase in oil and petroleum products transportation, and effects of a wide range of other developments, led to the initiation of the National Oceanic and Atmospheric Administration (NOAA) Marine Ecosystems Analysis Project (MESA Puget Sound). A two-year investigation of seasonal distribution and abundance of marine bird populations was begun in 1978 as part of this project by the Wildlife Science Group, College of Forest Resources, University of Washington, Seattle.

The purpose of this investigation was to characterize the marine bird populations from the mouth of the Strait of Juan de Fuca, east to Admiralty Inlet and north to the United States-Canada boundary. The study objectives included determination of the seasonal distribution, abundance, and species composition of marine bird populations throughout the study area; identification of spatial and seasonal patterns in abundance and distribution; identification of marine bird habitats and geographic areas of significant concentrations; and an update of published marine bird distribution and abundance data for the region.

II. CONCLUSIONS

This two-year investigation represents the most extensive study of marine bird distribution and abundance ever undertaken in Washington State.

Diving birds are the most vulnerable to the direct and indirect effects of oil pollution. Very large numbers of both breeding and transient diving birds were observed in the study area. Groups of vulnerable species present in particularly large numbers included loons, grebes, cormorants, diving ducks, and alcids. The direct effects of oil on birds include heat loss when oil mats feathers. Abnormal activity to increase heat production and feeding causes indirect mortality. Ingested oil can be toxic as well as interfere with normal organ functioning. Breeding birds with oiled feathers can contaminate eggs and reduce hatching success.

Breeding marine birds comprise about 40-89% of the total summer marine bird population, depending on the year. The presence of a relatively large percentage (60%) of all known breeding Rhinoceros Auklets in the contiguous western United States underscores the study area's importance to this species. Important breeding colony sites were somewhat concentrated at various points in that Tatoosh Island, Protection Island, Smith and Minor Islands, and Colville Island had 81% of the seabirds in the American portion of the study area.

The 116 species of marine birds observed in the study area indicate the richness of this region. Highest diversity is in the fall migration period. Species composition and abundance changes seasonally. This seasonality reflects migration periods and breeding season activities. In spring, two events contributed to large concentrations of birds. The spawning of herring, primarily at Discovery Bay, Cherry Point, and eastern Georgia Strait attracted large numbers of birds, especially Surf Scoters. The other event is the spring migration of Black Brant which brought over 50,000 birds to the eelgrass beds of the Padilla Bay area. With few exceptions, populations of all subregions peaked during the winter. This peak resulted from the influx of winter residents during late fall. Excluding cobble shorelines where herring spawning attracted large concentrations of birds, the highest consistent seasonal densities of birds were observed in shallow bays. Densities in those bays may be ten times larger than open water areas.

Several species of birds, particularly Double-crested Cormorants, various gulls and Rhinoceros Auklets make daily movements from roost or breeding sites to foraging areas. Most flights occur at dawn and dusk.

Roost sites appear to be an important aspect of the life history of marine birds in the study area. All roost sites were either totally or mostly undisturbed. Such sites included rocks and islands, spits, a few isolated beaches, log-booms, other man-made objects such as buoys, pilings and buildings, and the water surface (especially for diving species such as scoters, loons, grebes, and alcids).

At the present time, bird mortality from oil pollution and other sources appears to be very low. Important sources of mortality in the study area are presumed to be from gill nets, diseases, and parasites. Mortality rates, as revealed through beach bird surveys, are lower than comparable studies along the California coast.

Seabirds feed on a patchy resource, therefore their distributional patterns show both spatial and temporal short-term variations. These movements greatly affect census results on an hourly basis, but the longer term (seasonal) patterns tend to be more consistent and predictable. Seasonal trends are often striking, depending on the area and bird species.

This study clearly shows that there is a large amount of annual variation in numbers of seabirds using the study area. When the projected total numbers for the subregions are compared between years, only 13% show 10% or less variation between 1978 and 1979. Largest variation is for the summer when the mean difference is 186%. Annual variation in winter was not measured since there was only one winter censused. In general, birds were concentrated in the same areas during both years, but absolute numbers showed much variation.

In terms of individual species abundance, several species are noteworthy. The most spectacular influx of birds in the study area is that of the Common Murre in the fall. Each year there appears to be 100,000-200,000 murres in the Strait of Juan de Fuca. Since there are only about 100 pairs of murres nesting in the study area, it is obvious that the large numbers are from other parts of the North American West Coast. Limited observational evidence indicates that the fall population of murres originates from the coasts of California, Oregon, and possibly Washington. Murres also represent a large portion (about 16%) of the wintering birds in the study area. This species is one of the most vulnerable to oil spills. Therefore the large number in the study area represents a conservation concern.

Other abundant species include the large breeding populations of Rhinoceros Auklets on Protection and Smith Islands, the 60,000 or more Western Grebes that winter in the study area, the large concentrations of Surf Scoters that are attracted to spawning herring in the spring, and the 50,000 Black Brant that spend several weeks feeding in eelgrass beds in shallow bays.

The study area must be viewed as a dynamic system in which seasonal changes in bird species composition and abundance interact with the physical and biotic characteristics of the marine environment. The rich foraging habitats of protected bays, areas of convergence, kelp beds, and the ephemeral herring spawn all contribute to the large numbers of marine birds that spend part of their lives there. Birds are highly mobile animals and no one particular geographic location always supplies the species' life requirements.

Large-scale daily movements of Double-crested Cormorants from roosting to foraging areas, and Rhinoceros Auklets moving from the colony at Protection Island to three distant major foraging areas are important examples.

Based on the biological characteristics of birds and characteristics of each subregion of the study area, it is apparent that certain subregions are particularly vulnerable to the potential effects of oil pollution. This vulnerability varies seasonally. Areas of prime importance are listed in Table 1.

Table 1. The most important subregions of the study area.*

Subregion Code	Name	Season of Highest Vulnerability
0201	Strait of Juan de Fuca-Outer	Fall
0301	Strait of Juan de Fuca-Inner	Fall
0307	Jamestown	Spring, Summer, Winter
0310	Protection Island	Summer
0314	Smith Island	Summer
0316	Lopez Island (south shore)	Spring
0317	Admiralty Inlet	Summer, Fall
0504	Padilla Bay	Spring, Winter
0505	Samish Bay	Spring, Winter
0506	Bellingham Bay	Winter
0602	Cherry Point	Spring
0901	Southern Rosario Strait	Winter
0902	Central Rosario Strait	Fall
0903	Northern Rosario Strait	Spring, Fall
1103	Southern San Juan Channel	Summer

*See Section VI-B for explanation of ratings.

This study's extensive field sampling has provided a large volume of quantitative data. Few geographic areas of similar size have been studied as intensively during a similarly short period of time. The study has provided the first overall survey of all species and the varied habitats of the entire region. As such, it represents a very large first step in understanding the seasonal and geographical distribution of marine birds of the region and provides primary data to replace most review sources available to this time (see Salo 1975, Eaton 1975, Brittell et al. 1976, Lindstedt-Siva 1978). We stress, however, that the brief two-year time span of this study and limited frequency of sampling mean that the study only represents a first step in quantifying and characterizing the marine bird distribution and associations within the region. Several questions warranting further investigation are apparent and many are discussed elsewhere in this report.

III. RECOMMENDATIONS

A. Monitoring

Long-term systematic censusing of population abundance and distribution should be conducted. This is essential to determine long-term variations in populations and to measure impacts of possible perturbations within the ecosystem. A monitoring program should incorporate data from this study for benchmark purposes and utilize methods and census locations established during this study as much as possible.

B. Management

Wildlife management must keep pace with changing conditions, particularly the increasing pressure of human activities on seabird colonies, roosts and foraging areas. Educational programs aimed specifically at groups in contact with marine birds--boaters, divers, fishermen, nature observers and others--should be designed and pursued. Law enforcement capability should be increased.

C. Navigation Charts

We suggest that NOAA-NOS navigation charts be marked to designate bird colonies and roost sites and a legend notation inserted to briefly explain legal prohibition of landings, over-flights, and disturbance.

D. Food Webs, [illegible] Habitats

It is essential that thorough studies be initiated on specific seasonal prey items taken by marine bird species in the inland waters of Washington and British Columbia. At the present time we have only a general picture of the diets of important marine birds (Simenstad et al. 1979). Little is known about specific diet items of many species within this region. Accurate assessment of environmental impacts is possible only through knowledge of a species' biology. Knowledge of seasonal prey availability and food-chain dynamics must be better understood.

Likewise, the dynamic characteristics of many foraging habitats are poorly known. The operation and significance of tidal convergences in concentrating prey items and impacts of introduced oil on them, for example, appear to be unknown.

E. Bird Mortality in Fishing Nets

We strongly recommend that thorough research on bird mortality in fishing nets be undertaken. Observations of actual and presumed kills were incidental to our censusing, but suggest that in the study area this mortality may be substantial in areas of high fishing effort. Due in part to legal interpretation of treaty fishing rights and subsequent regulations, gill-net fishing in some important nearshore bird habitats (e.g., Bellingham Bay) has greatly increased recently. This may lead to an increase in mortality of Western Grebes. Data gathered, whether by on-board researchers or cooperating fishermen, should include standard items like date, time, location, environmental conditions, numbers, type of gear (including mesh-size), and also data needed to quantify birds caught per unit of fishing effort (i.e., per hour, net set, length of gill net). Reduction of both bird mortality and aggravation to fishermen can likely be made through use of comprehensive data from such a study.

F. Areas Outside the MESA-Puget Sound Study Area

The marine system is ecologically one large unit, and the subregions of the study area are interrelated. The various geographic units cannot be biologically isolated when considering major development proposals or assessments of large-scale or cumulative impacts on the system.

We have included several adjacent areas on the basis of published data acquired by others or ourselves. There is an obvious need to obtain comparable quantitative data on these areas. Studies using the same field methods and data analysis used in our study should be conducted for the remaining inland Washington waters: Puget Sound, Hood Canal, and the areas east of Whidbey Island. This is important because of proposed oil transport developments, especially at Saratoga Passage, the Snohomish estuary and Hood Canal. Knowledge of significant local avifaunal features and ability to evaluate these in context with areas studied under the MESA project are imperative.

IV. STUDY AREA AND METHODS

A. Region Descriptions

For analysis, we divided the study area into 13 regions (Figure 1, and Appendix Table A-1) and, in most cases, subregions that allow concentrations and variations in populations to be shown in greater detail. In some cases these divisions may have varied from those used in other studies. While this may be reflected in the calculation of density and vulnerability values, we feel the variations are minor and that our divisions were realistic.

Since we had few censuses in Canadian waters, some regions and subregions do not include Canadian shoreline or open water areas (Figure 1). Areas east of Whidbey Island were not a part of the study area, nor were waters of Puget Sound south of Admiralty Inlet.

1. Region 1. Swiftsure Bank (waters off the mouth of the Strait of Juan de Fuca).

This is an offshore area used for species composition and population comparisons with the Strait of Juan de Fuca regions and those farther east. We defined it as essentially between 48°15' and 48°35'N, and 124°45' and 125°05'W, and it includes part of Swiftsure Bank and outer continental shelf waters from about 60 to about 320 m depth.

2. Region 2. Strait of Juan de Fuca-Outer

This large region is bounded on the west by a line from Cape Flattery to Carmanah Point, Vancouver Island, and on the east by a line from Port Angeles to Race Rocks, British Columbia (Figure 1). It includes the waters of up to 300 m depth in midstrait and small shallow bays and estuaries such as Neah Bay, Clallam Bay, and Crescent Bay. Shorelines were otherwise characterized by rocky types with extensive kelp beds. Port San Juan, Sooke Harbor and Basin, and Becher Bay, British Columbia, are within the region but were not censused.

3. Region 3. Strait of Juan de Fuca-Inner

This region contains the eastern portion of the Strait of Juan de Fuca (Figure 1). Important subregions include Port Angeles Bay, Dungeness Bay and Harbor, Sequim Bay, Discovery Bay, and extensive open shorelines. Ediz Hook and Dungeness Spit are the largest of a number of accreted gravel spits protecting embayments. A variety of other shoreline types are present, including rocky shorelines, mixed fine beaches, and, particularly on the southern shorelines of the San Juans, continuous rock strata formations.

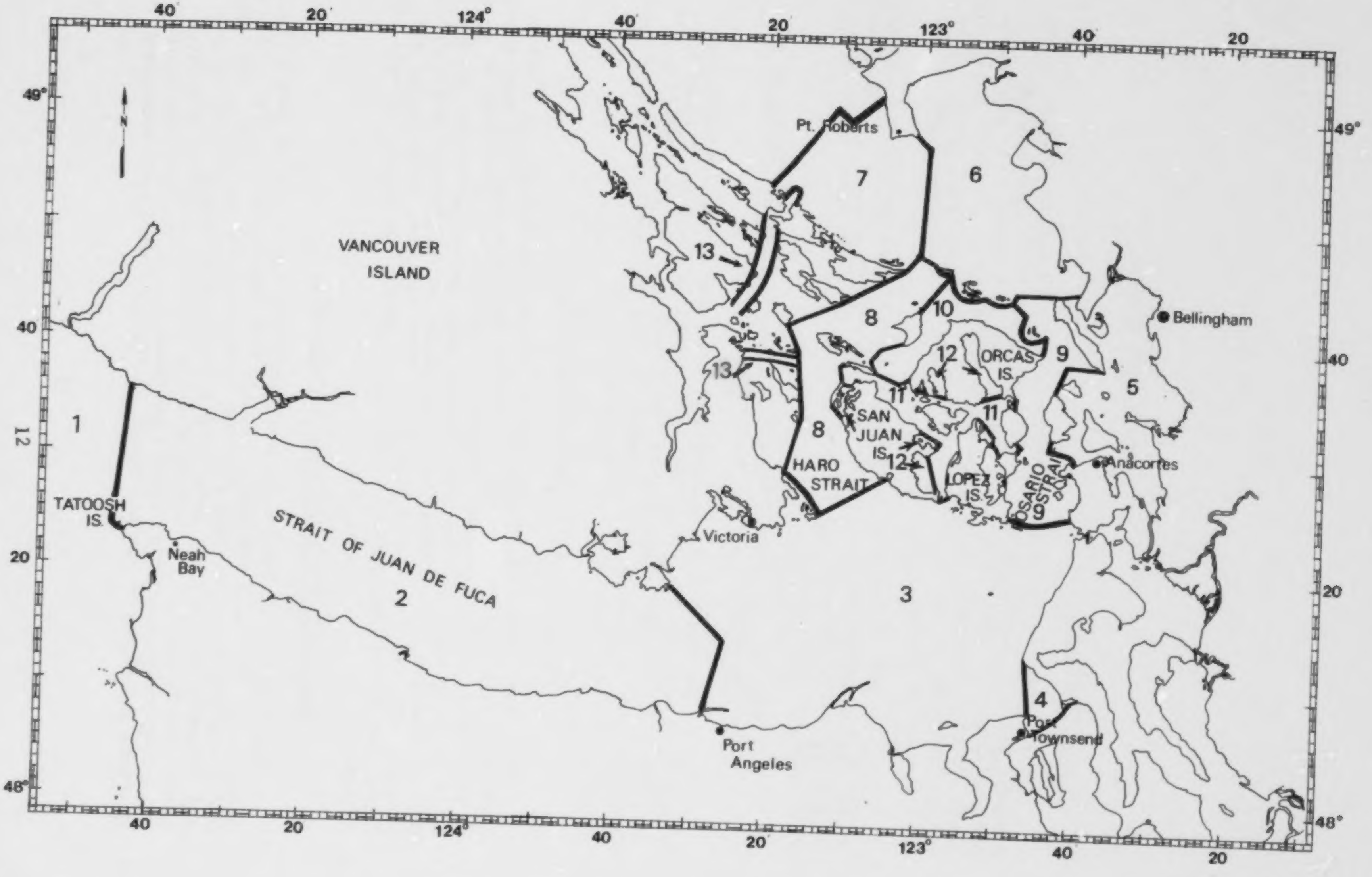

VANCOUVER ISLAND
STRAIT OF JUAN DE FUCA
TATOOSH IS.
Neah Bay
Victoria
Port Angeles
Port Townsend
Pt. Roberts
Bellingham
Anacortes
SAN JUAN IS.
ORCAS IS.
LOPEZ IS.
HARO STRAIT
ROSARIO STRAIT
1
2
3
4
5
6
7
8
9
10
11
12
13
N
124°
123°
49°
48°
40'
20'

Figure 1. Map of study area showing the 13 regions.

4. Region 4. Admiralty Inlet

This important foraging area is the turbulent channel exchanging waters between Puget Sound and the Strait of Juan de Fuca. Shorelines included in our study are limited in length but are primarily gravel and mixed types. Kelp beds are extensive.

5. Region 5. Inner Whatcom and Skagit County Waters

This region lies east of Rosario Strait, and includes as subregions Bellingham and Guemes channels, Fidalgo, Padilla, Samish, and Bellingham Bays, and Hale Pass (Figure 1). The bays in particular represent important shallow estuarine habitats. Sandy, rocky, and rock-strata shoreline types are all found within this region, as well as man-made dikes, breakwaters, and piers which form a greater part of the shoreline component than in other regions. Very large eelgrass beds are found in the shallow bays, whereas kelp and other algal communities are present in other shore and intertidal types. This region also is affected by considerable amounts of urban, agricultural, and industrial effluents, along with human disturbance and hunting. In general, this region has been more affected by human presence than other areas within the study area.

6. Region 6. Eastern Georgia Strait

The study area essentially ends at the United States-Canada boundary, and our coverage and data only partially include shallow and highly productive Boundary Bay, B.C., which is a significant feature adjacent to this study region and biologically part of it (Figure 1). Shorelines are primarily sandy, mixed and cobble, with bluffs backing beaches along part of the eastern shoreline. Eelgrass and kelp communities are present within the region.

7. Region 7. Western Georgia Strait

This deepwater region is influenced by low salinity/high turbidity surface waters resulting from Fraser River runoff. Offshore water depths range to over 200 m. Shorelines sampled in our study were essentially mixed gravel and sand, with associated kelp, and the shallow mud/sand bay with eelgrass at Tsawwassen. Productive waters of Roberts Bank and Sturgeon Bank immediately to the north along the British Columbia foreshore are not included in our study.

8. Region 8. Haro Strait

This deepwater region is the channel separating the San Juan Islands from Canadian waters (Figure 1). We have divided Haro Strait into northern and southern subregions by a line from Turn Point, Stuart Island to Fairfax Point, Moresby Island, B.C. Adjacent shorelines of the San Juan Islands are included within these regions, but shorelines on the Canadian side are not. Haro Strait itself is up to 300 m deep. Shores within our study boundaries are primarily rock strata, with one sizable shallow-shelf, low-beach component at Waldron Island.

9. Region 9. Rosario Strait

This deepwater channel separates the San Juan Islands and the northern bays and associated channels, passages, and islands (Figure 1). We divided Rosario Strait into northern, central, and southern subregions, using a line between Point Lawrence and Boulder Reef and a line from Pointer Island, near Thatcher Pass to Shannon Point. Rock strata/kelp shorelines, islands, and reefs predominate, and shallow shelves are found only in Burrows Bay and along the east side of Lopez and Decatur islands. Much of Rosario Strait is from 40 to 100 m deep.

10. Region 10. San Juan Islands, Northern Waters

This region is the northern tier of the San Juan Islands (Figure 1). A subregion comprising President Channel is separated from our "Northern Areas" subregion by a line from Terrill Beach, Orcas Island to Fossil Bay, Sucia Island. Offshore water depths range from 60 to 100 m. Shorelines are primarily rock strata, with adjacent kelp communities.

11. Region 11. San Juan Islands, Passages and Channels

Though they differ from each other, we placed channels and passages within the San Juan Islands into a geographically discontinuous "region" (Figure 1). The region includes Speiden Channel, Wasp Pass, Upright Channel, Harney Channel, Obstruction Pass, Thatcher Pass, and San Juan Channel which we divided into northern and southern subregions by a line between Friday Harbor and southern Point George, Shaw Island. Shallow shelves along shorelines are relatively narrow. Offshore water depths generally range between 40 and 100 m. Strong tidal currents are apparent in a number of locations. Kelp and other algal communities are widespread.

12. Region 12. San Juan Islands, Inner Bays and Sounds

Small bays or shallow areas adjacent to deep passages in the San Juans are grouped into a specific region (Figure 1). The Mosquito Pass-Roche Harbor complex, Friday Harbor, Griffin Bay, Fisherman Bay, Swift, Shoal and Blind bays, Lopez Sound, Deer Harbor, West Sound, and the shallow north end of East Sound are included.

13. Region 13. Canadian Gulf Islands

This region includes Canadian waters surveyed as a part of ferry censuses of adjacent American waters (Figure 1). It is comprised primarily of deep passages and relatively open waters and does not reflect a shoreline data component except in two relatively highly productive areas. These are the shoreline on the east side of Sidney Spit (included in the "Sidney" subregion) and the Active Pass subregion. Shorelines within the region are varied, including shallow, mixed shore types and gravel spits, but are often of continuous rock strata. Very strong tidal exchange occurs, especially in Active Pass.

B. Regions and Subregions

Subregions were created (occasionally arbitrarily) to best describe geographical or biological units. Within each subregion it is biologically necessary to distinguish between open "deeper" water habitats and shoreline "shallow" water habitats. These areas were often determined from NOAA navigational charts but tempered by field observations. Generally, shoreline water habitats are those areas next to shore and less than 20 m in depth.

For the open water and shoreline habitats of each subregion, a value representing the total surface area (in km^2) of each was calculated from NOAA navigational charts. Each region's total area is the sum of its subregions (Appendix Table A-1). Thus, the total of all open water and shoreline areas is known for the entire study area and its parts. These totals for the parts of the subregion were used to project the total number of birds in each family observed in the appropriate subregion habitat. These projections were made from the calculated mean weighted density for each family in each habitat type. To combine open water and shoreline is highly misleading. For example, a high species density along the shoreline of the Strait of Juan de Fuca-Outer (Region 2), a relatively small area, would project inflated numbers if extended to over 1,800 km^2 of the open water area.

C. Census Methods

Seabird censusing is affected by a virtually unlimited number of variables. Environmental conditions have significant effects on numbers of birds censused because they affect both the birds' behavior and their observability, as well as influencing the observer. There is considerable variation between observers in experience, visual acuity, and abilities to estimate flock size and distance. Bird behavior varies among species and by time and weather. Species observability and identifiability also vary greatly. Because of these variable observation limitations, our censuses in nearly all cases are minimum counts. Only rarely, if ever, do our counts represent exactly what is in the area surveyed, but most counts probably approach this level. Thus, our error is on the conservative side and all projections of numbers are necessarily understated. Our census methods closely parallel those developed and refined during the California and Alaska Outer Continental Shelf Environmental Assessment Program (OCSEAP) bird investigations. For pertinent discussion of assumptions and statistical treatments, see King (1970), Wiens et al. (1978), Briggs et al. (1978), and Dixon (1977).

Data from our aircraft and vessel censuses are probably somewhat more variable than similar data taken by Briggs et al. (1978) and Wiens et al. (1978) for several reasons. Compared to their essentially straight-line, open-water census tracks, many of our census segments were relatively short, along shorelines and around islands. This increased the effects of tidal variation, complex geographical features, habitat diversity, and shadow and reflection contrast. Our aerial census segments were also often glare-affected and, because habitats and numbers varied greatly from one side of the aircraft to the other, we could not simply elect to omit glare-side censuses along shorelines as can be done over open water.

Many of our censuses were done from shore locations. Data obtained on these censuses are probably more consistent and are unaffected by time constraints inherent in censuses from moving vessels, particularly from aircraft, where virtually instantaneous perception, identification, and counting or estimating numbers are required.

We feel that observer errors tend to be random and, as noted above, that our methods, both in field data acquisition and in analysis, give conservative census counts and subsequently conservative projections. Our methods were consistent in all geographical subdivisions and our results, analyses, and ratings of subregions are comparable for purposes of this study.

1. Types of Censuses

All censuses were conducted at designated locations of known area or over designated routes. Census areas were selected to sample all geographic regions and habitat types within the study area. Census points for these areas were selected to maximize coverage within the constraints of accessibility and time.

Census segments covered from moving vessels such as small boats, ferries, or aircraft are designed to sample habitat types. Almost all such segments are approximately 2 to 8 km long, though two long segments over the open waters of the Straits of Georgia and Juan de Fuca were 20 km and 96 km long, respectively.

In order to characterize habitats and accurately depict census locations, regions, and subregions, our census areas are classified in the following manner.

(1) Bay and harbor censuses--Enclosed or nearly enclosed bodies of water. These censuses were conducted from shore locations, small boats, and aircraft.

(2) Shoreline censuses--Along open shores of mainland or large islands adjacent to large bodies of water, with censusing from shore or from vessels or aircraft looking toward shore.

(3) Small island and rock censuses--Small land units actually or potentially used by seabirds as nesting, roosting, or resting sites. Censused from aircraft or small vessels.

(4) Open water censuses--Fixed-transect width counts over large bodies of water and at least 500 m from adjacent land areas. Censused from aircraft, small boats, or ferries.

While some censuses of small passages, estuaries, and bays covered virtually all the surface of the defined census area, not all birds present were observed even in these small areas; consequently, our censuses represent samples.

The total census effort for 1978 and 1979 is presented in Tables 2 and 3.

Table 2. Census effort, by census types, in 1978 and 1979.*

Type of Census	1978	1979
Aircraft	1,610	1,300
Beach Census	152	38
Beach Walk	182	45
Boat	276	374
Ferry	703	925
Point Census†	588	768
Sea Watch	156	61
Total	3,667	3,511

*Numbers are the total number of censuses performed in all areas for each census type.

†Point Census totals are computer census units. Many census units represent several separate censuses which are summed. Point census units in 1979, for example, actually represented 3,439 censuses.

Table 3. Census effort by season, all census types combined.*

Season	1978	1979
Spring (April-May)	1,012	681
Summer (June)	139	366
Fall (July-October)	1,161	996
Winter (November-March)	1,203	1,266
Total	3,515	3,309

*Numbers of censuses used in calculations of subregion estimates (Appendices D, E & F). For technical reasons, a number of censuses listed in Table 2 were not used in these calculations.

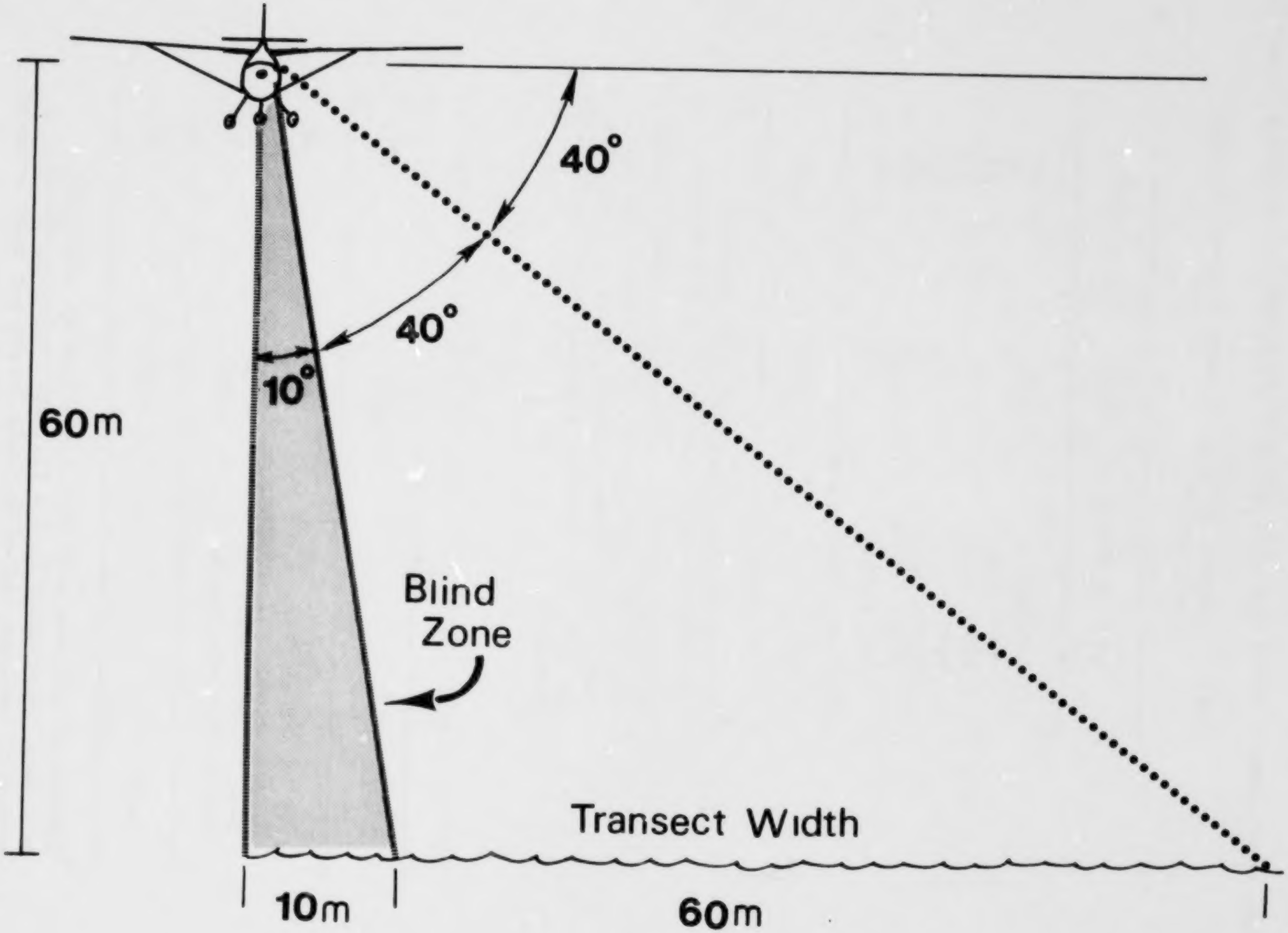

40°
40°
10°
60m
Blind
Zone
Transect Width
10m
60m

Figure 2. Diagram of one aircraft census zone.

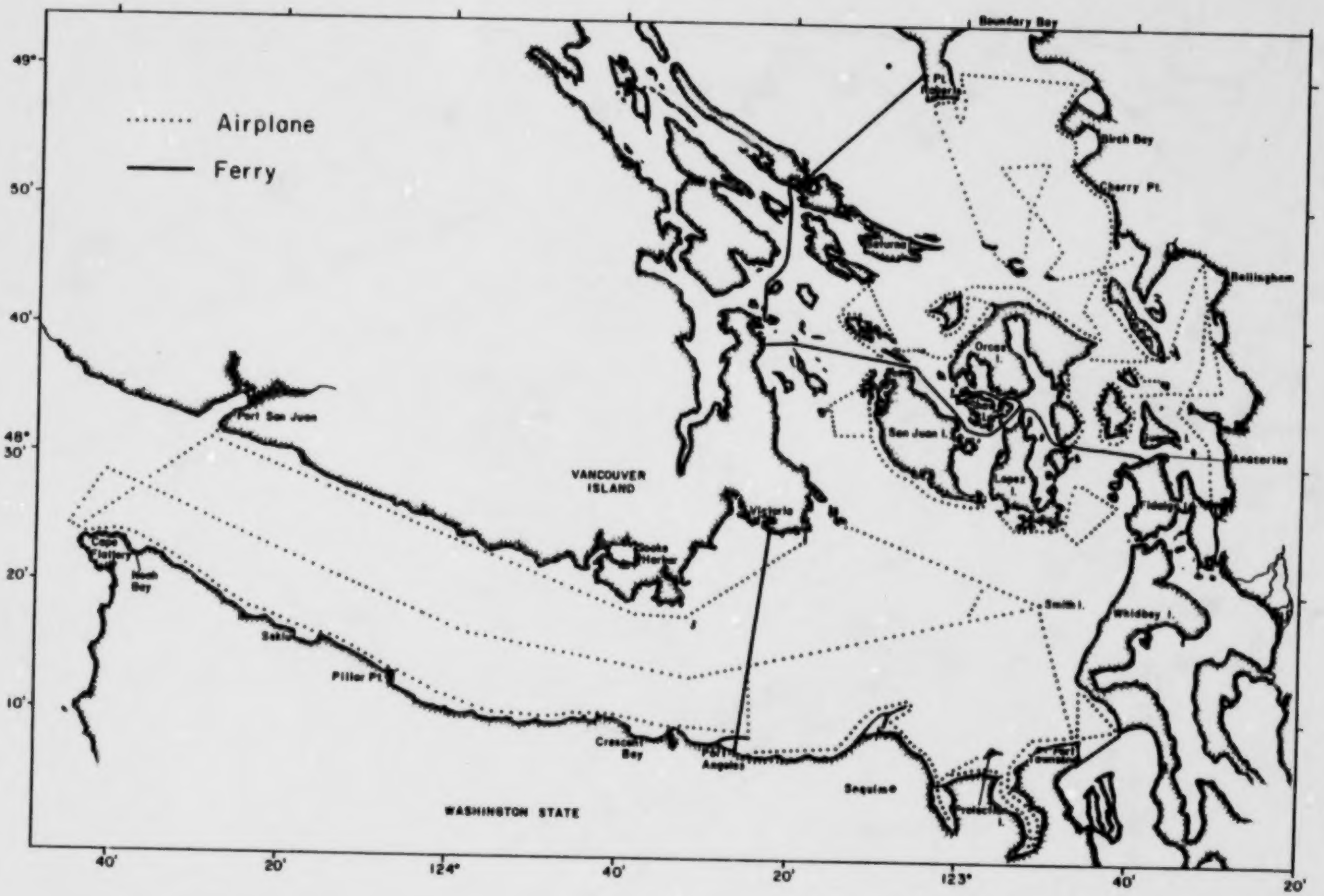
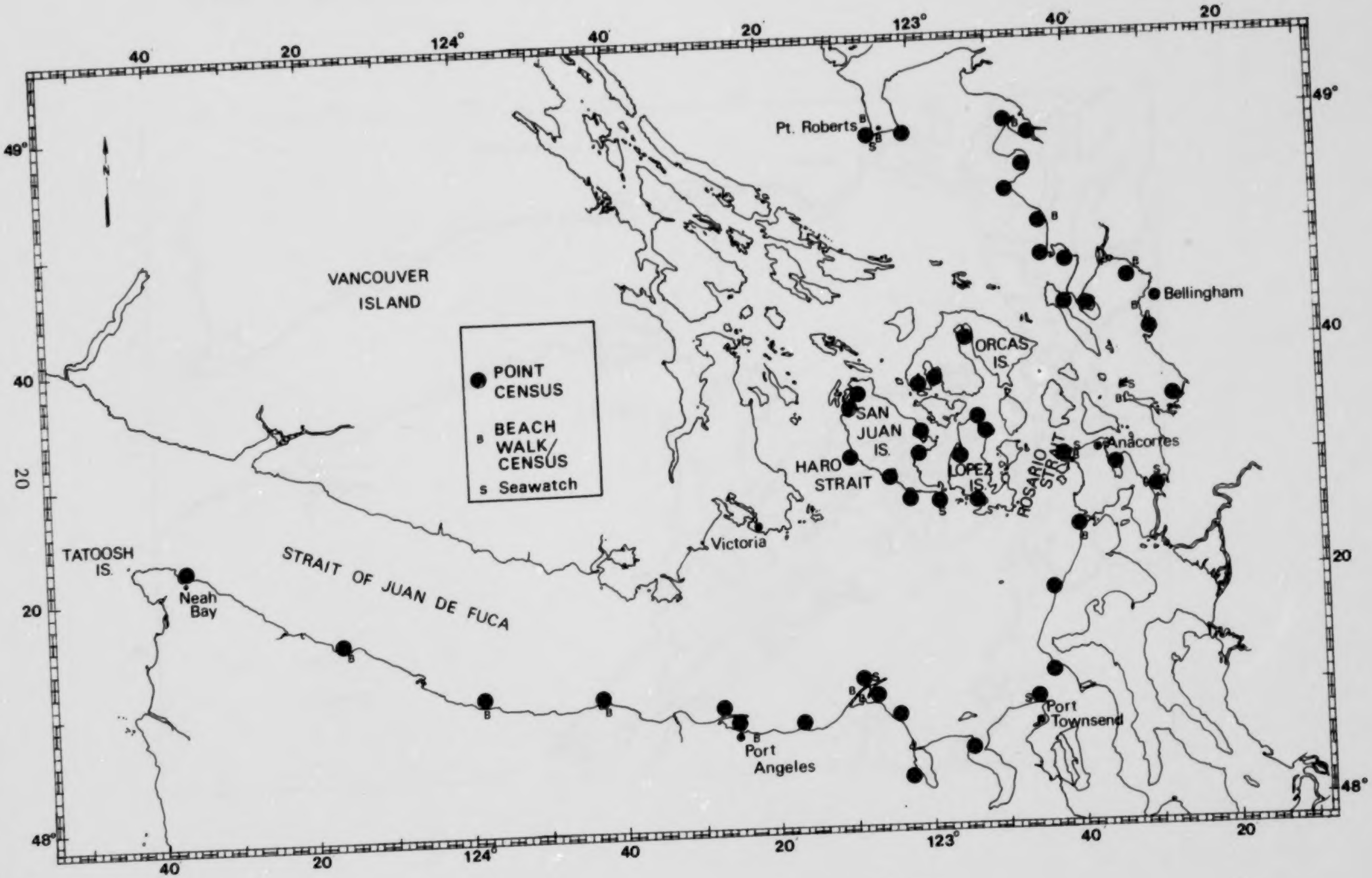

Airplane
Ferry
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Victoria
Sooke Harbor
Port San Juan
VANCOUVER ISLAND
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Port Townsend
Protection I.
WASHINGTON STATE
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 3. Map of the study area showing the aircraft and ferry census routes.



POINT CENSUS
B BEACH WALK/ CENSUS
S Seawatch
VANCOUVER ISLAND
STRAIT OF JUAN DE FUCA
TATOOSH IS.
Neah Bay
Port Angeles
Victoria
HARO STRAIT
SAN JUAN IS.
LOPEZ IS.
ORCAS IS.
ROSARIO STRAIT
Anacortes
Bellingham
Pt. Roberts
Port Townsend
N
124°
123°
49°
48°
40
20

Figure 4. Map showing study area point census and sea watch locations.

a. Aircraft Census. Monthly censuses of birds were made from a Cessna 172 aircraft flying about 60 m above the surface at a speed of about 148 km/h (80 kt/h). One observer on each side surveyed a transect width of about 60 m by unaided eye, covering a 40° arc from about 40° below horizontal to about 10° above vertical (see Figure 2). This assumes an uncensused "blind area" beneath the aircraft about 10 m wide. Aerial transect routes are shown in Figure 3.

b. Point Census. This is a periodic census of all birds, flying or on the water or shoreline, visible from designated shore locations. Using binoculars and telescope, censuses were conducted by a thorough, deliberate scanning of the area. Duplication of census areas (as in bays) was avoided by use of reference points.

Point censuses were used to sample bays and open shorelines such as Cherry Point, Whidbey Island, and Point Roberts (Figure 4). The area covered was calculated from (1) the bird observability distance which was determined by the elevation of the observation location, (2) reference points checked from standard National Ocean Survey marine charts, and (3) observation conditions at the census site.

c. Sea Watch. A sea watch consisted of counting all birds moving past a designated point as the observer watched in a fixed, predetermined direction. Direction of movement and standard bird and environmental data were recorded. Telescopes were used at most locations, though binoculars were used at Point Roberts where bird movements were predominantly close inshore. Census periods were of 30 or 60 min, primarily for 2 to 3 hours after dawn, and for 2 to 3 hours before dark. The purpose of this type of census was to determine migration and daily movements. A single observer made observations in each census. Locations of sea watches are shown in Figure 4.

d. Beach Census. This was a count of all birds along a known length of beach, from approximately high tide line to 100 m offshore. Meaningful counts required censusing early in the day before birds were disturbed by humans and dogs. The purpose of a beach census was to provide samples of inshore populations along different shoreline habitat types. One observer on foot usually conducted each census. Beach census locations are given in Figure 4.

e. Dead Bird Census (Beach Walk). Beach walks were censuses on foot along known lengths of beach, searching for dead birds from water's edge to upper tide levels. Species, age, sex, state of bird, cause of mortality, oiling, condition of water and beach, and disposition of birds were recorded when possible. Beach walks were usually conducted as the return leg of a live-bird beach census. Specimens were occasionally salvaged and deposited in the Burke Memorial Museum, University of Washington. A total of 194 beach walks were made in 1978 and 1979. In addition, dead birds were noted when observed on all censuses from small boats, ferries, and aircraft (Table 4). Locations of beach walks are given in Figure 5.

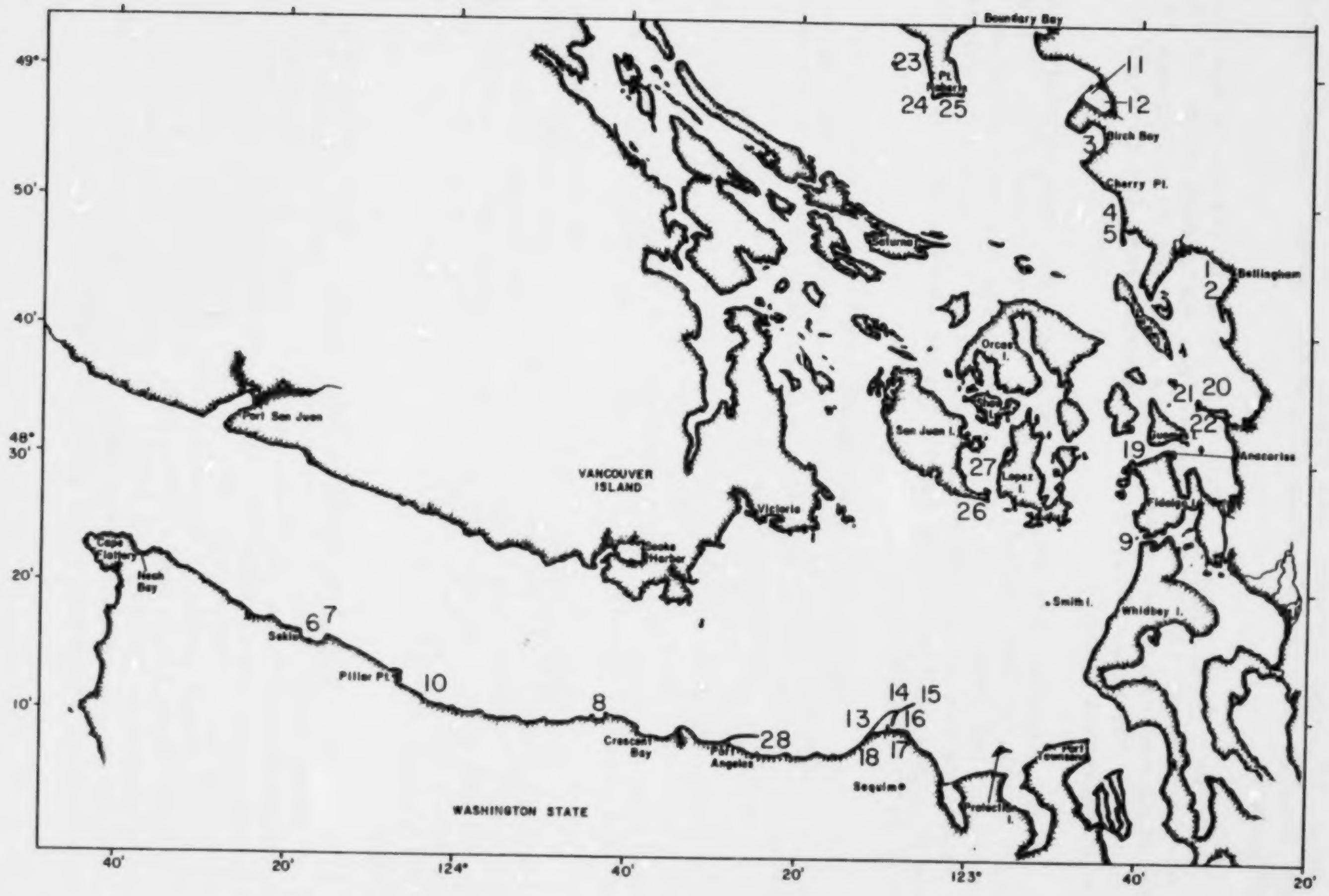

Boundary Bay
23
Pt. Roberts
24 25
11
12
3
Birch Bay
Cherry Pt.
4
5
1
2
Bellingham
Orcas I.
21 20
22
19
Anacortes
San Juan I.
27
Lopez I.
26
Fidalgo I.
9
Whidbey I.
Smith I.
VANCOUVER ISLAND
Victoria
Sooke Harbor
Port San Juan
Cape Flattery
Neah Bay
6 7
Sekiu
Pillar Pt.
10
8
Crescent Bay
Port Angeles
28
13
14 15
16
17
18
Sequim
Protection I.
Port Townsend
WASHINGTON STATE
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 5. Map showing study area dead bird census (beach walk) locations.

Table 4. Number of dead bird surveys on Washington State ferries and aircraft in 1978 and 1979.*

	Wint '78	Spr '78	Sum '78	Fall '78	Wint '78-9	Spr '79	Sum '79	Fall '79	Wint '79
Ferries									
1. Strait of Juan de Fuca	2	2	4	10	9	2	2	4	3
2. San Juan Islands	10	10	2	9	13	6	2	13	5
3. Georgia Strait	4	7	2	8	10	4	2	8	4
4. Admiralty Inlet	4	3	0	3	10	4	2	13	3
Airplanes									
1. Strait of Juan de Fuca	3	5	0	4	4	2	1	2	1
2. San Juan Islands	1	3	0	3	4	4	1	2	1

*Total number of beach walks was 194 in 1978 and 46 in 1979. See Table 8.

f. Small Boat Census. Seasonal in-motion censuses of open waters, shorelines, and small islands or rocks (colonies or roosts) were conducted from outboard-powered vessels under 7 m long, though privately chartered vessels of 15 to 30 m length were used on several occasions. Censuses from small vessels supplemented, and also occasionally duplicated, those done by aircraft or ferries. Emphasis was placed on censusing areas inaccessible to or unfeasible to census through other methods.

g. Ferry Census. Censuses of open waters, passages, and along some shorelines were made monthly by experienced observers aboard ferries between Port Angeles and Victoria, B.C. (referred to below as Strait of Juan de Fuca ferry), Port Townsend and Keystone (Admiralty Inlet), Anacortes and Sidney, B.C. (San Juans), and Tsawwassen--Swartz Bay, B.C. (Georgia Strait) (Figure 3). Binoculars were used to verify unaided eye sightings when necessary over a 500-m transect width on one or both sides of the vessel. (This was determined and periodically calibrated by use of a simple range-finder adapted from Wiens et al. 1978.) The observer normally censused a 90° arc from bow to side, on the side offering the best observation conditions at the start of the trip, with the opposite side covered on the return trip. Both sides (180° arc) were occasionally censused during the periods of low bird abundance. Census locations were set to provide separate open water and shoreline habitat data. Ferry censuses were usually done on a round-trip basis.

h. Breeding Bird Surveys. Data on breeding bird colonies were obtained by circumnavigating 138 suitable islands in the study area by boat during the summers of 1978 and 1979. All possible sites were examined. Estimates were made from counts of birds at the colony-sites. This technique is suitable for surface-nesting species, but hole-nesters require more time to count burrows or determine occupation of crevices. Only on Tatoosh and Smith Islands were land surveys made of burrows and nests. Species such as the Tufted Puffin and Rhinoceros Auklet require this additional effort. Our data on these species for Protection and Smith Islands were obtained from Wilson (1977) and Manuwal and Campbell (1979). Additionally, estimates of the total number of nesting Pigeon Guillemots and Marbled Murrelets for the entire study area were obtained by the standard aerial and point censuses, since these species are not always easily counted around their nest-sites. The projected total numbers for each subregion were then summed to obtain the regional total.

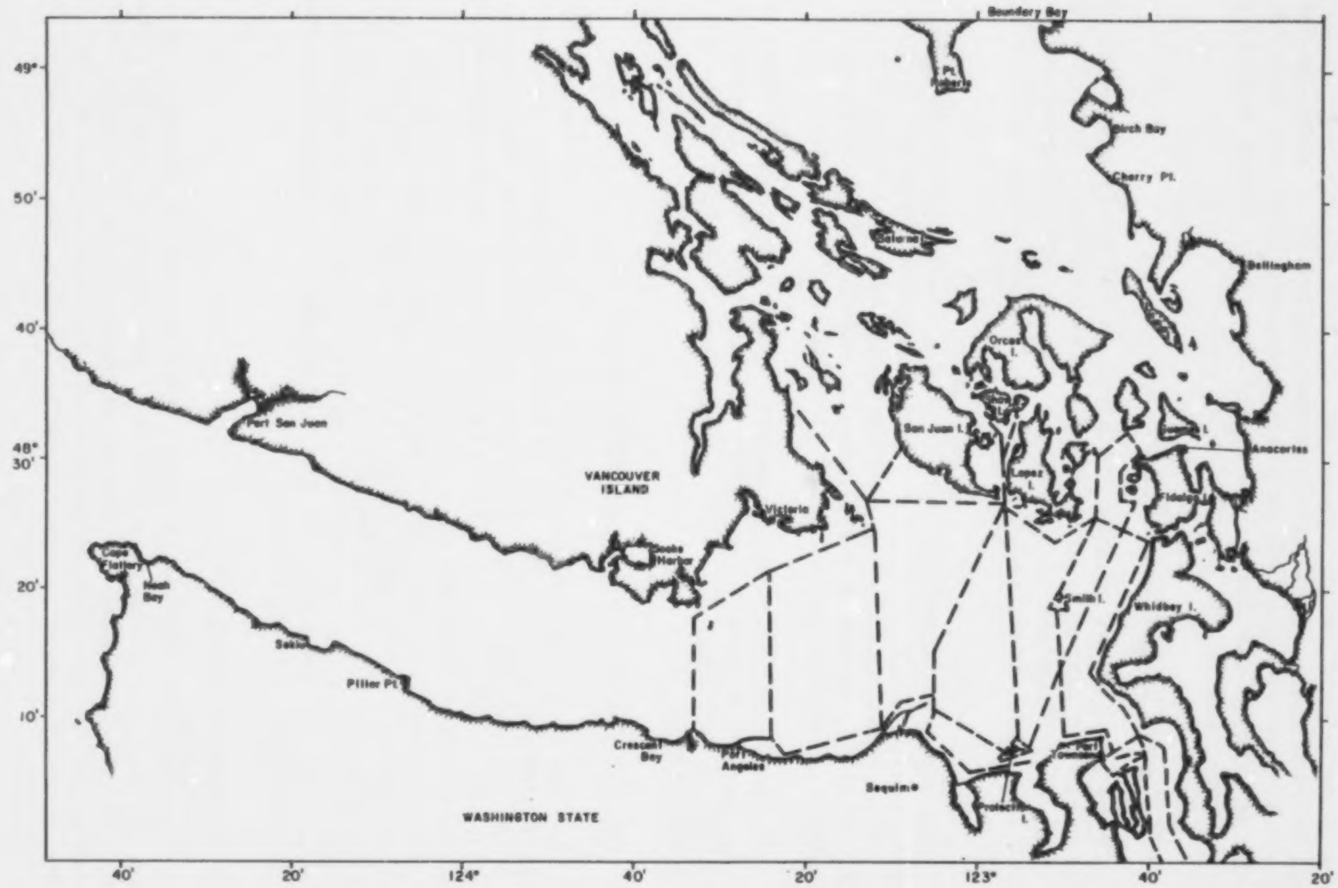
i. A Special Census, the Rhinoceros Auklet. In July 1979, an attempt was made to determine the nature of the daily foraging pattern of Rhinoceros Auklets feeding young on Protection Island. To this end a web of aircraft census routes (Figure 6) was established and surveyed in the standard aircraft census manner. Movements of birds into and out of the Strait of Juan de Fuca eastern basin were quantified through the use of sea watches at various key points.

D. Field Observations

Sampling consisted of counting or estimating numbers of individual seabirds (and marine mammals) of all species observed, by age, sex, or color-phase where feasible. Count data from aircraft or vessels were recorded on tape cassettes and transcribed at earliest convenience onto census tabulation forms. Tape recording of observations made daily fieldwork more efficient in: (1) quantity of data collected per trip, requiring less time to census a given area; (2) greater accuracy and completeness of sightings; and (3) maximized use of observer travel time and resources. Fixed location shore censuses were usually tape recorded, though some observers recorded directly onto field record sheets.

Environmental conditions (wind direction on 8-point compass scale, cloud cover in oktas, sea state on Beaufort scale, and notes on precipitation or observation conditions) were recorded by the observer, as well as local starting and ending times. In aerial censuses, these data were recorded by a "navigator" who also called out transect numbers to observers and assisted the pilot.

Censusing accuracy was enhanced by use of observers experienced with the species involved, the region, and with censusing methods. A very limited number of observers conducted all moving transects or shoreline censuses from aircraft, small boats, or ferries. Consistent censusing techniques and observer quality, employed within a narrow range of suitable observation and environmental conditions, were objectives at all times.



Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Galiano I.
Bellingham
Orcas I.
Shaw I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port Townsend
Protection I.
Sequim
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
WASHINGTON STATE
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 6. Map of the Rhinoceros Auklet study aircraft census route.

E. Bird Species Observability

During a given observation period an area may have been censused using several census types which were often repeated in order to calculate the density of each family. In light of the exceedingly difficult problem of equivalence between census techniques, we took all our data at face value. Thus, in most cases, our counts are underestimates of each species present. Obviously, some species such as Glaucous-winged Gulls are very visible even in unsettled weather and are seldom missed, but some diving species are more easily overlooked by the observer(s).

F. Avian Taxonomic Considerations

In this study, we counted all birds in the study area that are normally associated with either freshwater or marine habitats. The term "marine birds" is meant to include all birds observed in the habitats previously described. "Seabirds" refer specifically to auks, gulls and terns, storm-petrels, and cormorants.

Our analysis is made primarily at the family level throughout this report, except where particular species/phenomena warrant further discussion. As a rule, families not only represent taxonomic units but ecological units as well. Clearly, grebes are ecologically distinct from loons and alcids. Likewise, cormorants are distinct from gulls, herons, etc.

Throughout this study and report, species and family vernacular names follow those used in the AOU (1957) Checklist of North American Birds and its supplements (1973 and 1976) and those found in Robbins et al. (1966) and Peterson (1961).

G. Species Identification and Field Codes

All birds observed were identified to the species level whenever possible. Species names were recorded on field forms and later on computer code sheets in a four-letter coded form derived from the species names, i.e., Glaucous-winged Gull--GWGU, Northern Shoveler--NOSH, Marbled Murrelet--MAMU. If species-specific identification was not possible, then the bird was coded at the next higher level of classification, i.e., large Cormorant (Brandt's/Double-crested)--LACO, gull--GULL, small Loon (Arctic/Red-throated)--SMLO. Subspecific identification was not attempted in general, as this was not an object of the project nor was it possible to make such determinations in the field. Persons interested in such refinements of identifications must refer to appropriate taxonomic works.

H. Data Preparation

All cassette tapes were transcribed as soon as possible after returning from the field. All data sources were summarized by species, then age, and sex, and the respective environmental observations classified for each site. After summarizing, the data were coded onto keypunching sheets. Data thus coded included number by species, age, and sex, the four-letter species code, environmental data (cloud cover, wind direction, and Beaufort scale), observer(s), time start and elapsed time, date, station/segment, and observation platform/area surveyed. Local time and date were converted to Greenwich Mean Time and also recorded. At this time, the Julian Date and census number were assigned, and after a visual check of the coding sheets they were given to the keypunching service for data card preparation.

After the cards were punched and verified they were then listed and the listings were checked for errors. At this point, the data cards were read onto a disk file in the computer center and transferred to a storage tape. Here, an editing program was run on the data set checking for appropriate character ranges in each field. After errors were corrected on disk using a screen and edit package, two cross-reference programs were run on the data set. One cross-reference program matched our field species code to the NOAA/NODC (National Oceanic Data Center) twelve digit species code and filled in the code number in the appropriate fields. Any discrepancies were given as error messages and they were corrected at this time. The second cross-reference program matched the station/segment-platform/area surveyed code with various appropriate location data--latitude, longitude, habitat types, segment length and area, and water depth. Any discrepancies were given as error messages and they were corrected at this time. After these operations were completed, a listing of the data set was obtained and again visually inspected for errors. The data sets were managed in monthly packages. After all editing was completed the data sets were transmitted to the NODC for archiving. Data sets may be obtained by contacting Dr. James B. Ridlon, MESA Data Coordinator, NOAA/EDIS/NODC, 2001 Wisconsin Avenue, N.W., Washington, D.C. 20235.

I. Data Analysis

During the 1978-1979 survey period, nearly 90,000 records were generated on five record types. The first two types contain all relevant location, observer, and environmental data. The third record type contains the species data, with each card representing the total observed of each species at a site or segment. The fourth record type contains data on dead birds when they were observed at a site. The fifth type is text with noncodable data such as observations of feeding flocks, roosting areas, and marine mammals. These five record types represent the package of data collected at a given site or segment, with a unique set generated each time the station was censused.

All record types contain the File Identification number, record type number, and site/segment code. Thus the cards for a given census are uniquely linked. In addition to this linkage, we assigned every site/segment to a region and subregion (see Appendix Table A-1) with a site/segment occurring in only one region/subregion. For analysis, the data sets were sorted first by date, period (spring summer, fall, and winter), and region/subregion. Within the last breakdown the sites were further sorted as belonging to open water (i.e., Strait of Juan de Fuca or open water of Bellingham Bay) or shoreline (i.e., Dungeness Spit, Cherry Point). An area (subregion) such as Bellingham or Sequim Bays contains both open water areas such as in the center of the bay and shoreline areas. Other subregions may contain only shoreline or open water habitats (see Appendix Table A-1).

J. Observation Seasons

We divided the year into seasons based on generalized marine bird activity cycles within this region. "Spring" was April and May, the period when birds migrate through and into the study area. "Summer" was June, when the population consists primarily of summer resident species, nonbreeding individuals of species nesting outside our region both to the north and in the southern hemisphere, and a small number of migrants. "Fall" was July through October, and includes the principal southward migration of birds summering to the north of our region and those species which nest here and move south for the winter. "Winter" was from November through March. There was much overlap between species and yearly variation in these seasons.

Tables 2 and 3 contain the seasonal frequencies of all census techniques utilized in this study in 1978 and 1979. In 1978 a total of 3,667 censuses were performed and in 1979 the total number of censuses performed numbered 3,511. Table 4 shows the number of dead bird surveys conducted in both years.

K. Marine Bird Density

It is of prime importance to project by season the expected total number of birds present in each family in each subregion, and to do this the Mean Weighted Density (MWD_f) of each family was calculated. This is given by equation (1),

$$MWD_f = \sum_{i=1}^{n} \sum_{j=1}^{n} (n_{ij})(a_j/\Sigma a_j)(1/a_j) \qquad (1)$$

where n_{ij} is the total number of the $\underline{i}^{th}$ species observed in the $\underline{j}^{th}$ census (segment/station), and Σa_j the total of areas of all censuses performed, including those for which no species of a particular family was observed. The term $(a_j/\Sigma a_j)$ is a factor which weights the contribution of a census in determining the MWD. Thus a census that covers only 0.1 km^2 will contribute less to the MWD than one that covers ten times that area. However, it is seen that (1) reduces to (2)

$$MWD_f = \sum_{i=1}^{n} \sum_{j=1}^{n} (n_{ij}/\Sigma a_j) \qquad (2)$$

These MWD_f values are used for each family, period, and subregion for 1978 and 1979.

L. Projected Total Numbers

From the MWD_f values it was possible to project the total number of birds in each family probably present in the open water and shoreline components of each subregion (3) during each period

$$PT_f = (MWD_f)(A_k) \quad (3)$$

where A_k is the subregion area made up by shoreline or open water habitats. The subregion and region projected totals for each family (PT_f) were obtained by summing the appropriate species PTs.

Unfortunately, densities and projected totals for species and families are in themselves important but of limited value in trying to make management decisions relating to the appearance of oil on the water surface normally and naturally occupied by birds. Clearly, there is an intuitive feeling that the loss of a loon is of greater consequence than the loss of a Glaucous-winged Gull, or the loss of a Western Grebe (few in number) as compared to a Bufflehead (many in number). To quantify these qualitative and quantitative features of species we referred to an "Oil Vulnerability Index" created by King and Sanger (1979) for use in Alaska. However, after careful examination of their system, it became apparent an index system was needed to reflect the status of birds in the Washington marine environments. To this end we created a Bird Oil Index (BOI).

M. Bird Oil Index

Bird species differ in many biological attributes such as nesting, foraging, social behavior, and response to floating oil. An analysis of these attributes is important in not only assessing the "value" of each species but also in estimating the relative importance of marine habitats such as bays, shorelines, channels, and passages to birds.

The Bird Oil Index helped us evaluate the importance and vulnerability to oil pollution of the subregions. Several different natural history aspects make a particular bird species vulnerable to oil. These are species that exist in small populations, have low fecundity, have restricted feeding and winter distributions, often occur in larger flocks, and dive from danger or for feeding. The Bird Oil Index should only be used when evaluating the effects of oil. It does not apply to other types of major perturbations. The BOI ratings thus identify species particularly vulnerable within the study area due to behavior, abundance, and other attributes. Species that scored high because of these factors include Arctic and Red-throated Loons, Western Grebe, Brandt's and Pelagic Cormorants, Black Brant, White-winged, Surf and Black Scoters, Black Oystercatcher, Common Murre, Pigeon Guillemot, Marbled and Ancient Murrelets, and Rhinoceros Auklet. These are all either diving birds or very specialized as to diet (brant) or habitat type (oystercatcher).

The BOI is an attempt to quantify the various aspects of behavior, biology, and distribution and abundance as related to exposure to uncontrolled oil on the water surface. This index is intended for use with all marine birds of Washington. Details for the assignment of category ranking and calculation of each species' BOI value are presented in Appendix B. In short, there are three major components of the BOI, each equally contributing on a scale of zero to ten, with the BOI value for any species potentially running from 0 to 1,000. The first component deals with the habits of individual birds as they relate to the vulnerability of the species to spilled oil (reacting, escape behavior, flocking on water, nesting concentration, and feeding [foraging] specialization). The second relates to the total population and its vulnerability to oil (population size, reproductive capacity, breeding dispersion, winter dispersion, and seasonal exposure to waters on which spilled oil could appear). The third component relates the significance of our populations to the total population and the effects spilled oil could have during the four seasons.

A family BOI_f score was calculated for habitat type, each season, and for each subregion. The calculation of the family BOI_f value is given by

$$BOI_f = 10^{-4} \sum_{i=1}^{n} BOI_i \; A_k \sum_{j=1}^{n} (n_{ij}/\Sigma a_j) \qquad (4)$$

where BOI_i is the BOI for the $\underline{i}^{th}$ species of the given family. The other terms are as above.

As a further tool to evaluate various bodies of water it is helpful to know the number of BOI units that are present in each km^2. This is not a density figure in the literal sense, as we are not talking about birds per unit area but their BOI value per km^2 as given in (5).

$$BOI_f/km^2 = BOI_f/A_k \qquad (5)$$

BOI/km^2 is an expression of the projected "importance-vulnerability" per km^2. The appropriate subregional and regional totals are the sums of the BOI_f values.

N. Rating of Subregions

Each subregion was rated in two ways, one on the basis of its BOI (total) value score and second on its BOI/km^2 score. These two ratings were then averaged for both years, producing an average rating for each subregion, thus adjusting for variations in subregion size. These average ratings were then ranked on a five point scale and were then adjusted upwards to take into account either the presence of marine bird breeding colonies or of roosting areas. The two techniques allow easy presentation and interpretation of otherwise large and hard-to-digest sets of data.

These subregional ratings are for guidance in assessing potential vulnerability of bird populations to oil spills. For considerations of other impacts of short-run local disturbances, the seasonal rating may be generally suitable. For consideration of impacts of permanent habitat alteration or large-scale, long-term disturbances, the highest, most critical rating is applicable.

V. RESULTS AND DISCUSSION

A. Breeding Marine Birds

Marine birds were found breeding along much of the shoreline and in many island habitats of the study area. Most nesting sites were concentrated on islands in the San Juan Islands and in Rosario Strait, on Smith and Minor Islands, Protection Island, and Tatoosh Island. In Canadian waters there were several colony sites in the Gulf Islands. Mandarte Island, near Sydney, Vancouver Island, was the most important colony site in the area and Race Rocks near Victoria, Vancouver Island, was another important nesting site (Campbell 1979).

In U.S. waters approximately 34,300 nesting pairs of 12 species were found nesting. The Canadian waters included in this report contained about 5,000 nesting pairs of seven species. Thus, nearly 39,300 pairs of birds were nesting in the study area and adjacent Canada (see Table 5 and Figures 7 through 21).

B. Regional Accounts of Breeding Birds

The locations and numbers of all breeding species, as of the end of 1979, are presented in Table 5. Unless otherwise noted (see Table 5) these data were collected as part of this study in 1978 and 1979. For most species, data were obtained by on-site counts at each nesting site and numbers may represent an average of censuses from two years. The Pigeon Guillemot and Marbled Murrelet were widely dispersed nesting species that cannot, for the most part, be censused by the same techniques used for the other nesting species (see Binford et al. 1975, and Simons 1980). Numbers of nesting Pigeon Guillemots were derived in part from on-site counts and in part from an average of data from regular distribution censuses in 1978 and 1979. There are no known nests of the Marbled Murrelet in Washington, although it is clear that the Marbled Murrelet is a widespread nesting species in Washington. Therefore, numbers for Marbled Murrelets were projected from an average of all regular census data obtained in 1978 and 1979.

1. Region 1. Swiftsure Bank

Birds nesting on Tatoosh Island and other islands along the outer coast of Washington undoubtedly forage in part of this offshore region.

2. Region 2. Strait of Juan de Fuca-Outer

The most important colony in this region was located on Tatoosh Island, which was the most diverse colony of the study area. It was characteristic of

Table 5. Regional, subregional, and island summary of breeding seabird populations in 1978 and 1979.

		Region/Subregion Number	Island/Site Number	SPECIES Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Double-crested Cormorant	Pelagic Cormorant	Black Oystercatcher	Glaucous-winged Gull	Common Murre	Pigeon Guillemot	Marbled Murrelet	Cassin's Auklet	Rhinoceros Auklet	Tufted Puffin	Island/Site Total	Regional Total
Region	Swiftsure Bank	01--															
Subregion	Swiftsure Bank	0101															
	Regional total																
Region	Strait of Juan de Fuca-Outer	02--															
Subregion	Strait of Juan de Fuca--Outer	0201															
"	Vancouver Island	0202															
"	Cape Flattery	0203									(10)	(1)					
	Tatoosh Island		1	300	500		200	4	2,000	100	40		300	300	75	3,819	
"	Neah Bay	0204									(2)	(4)					
"	Neah Bay to Clallam Bay	0205									(20)	(25)					
	Seal and Sail Rocks		2				20	+	15		+				25	60	
"	Clallam Bay	0206									(2)	(15)					
"	Clallam Bay to Crescent Bay	0207									(80)	(4)					
"	Crescent Bay	0208									(15)	(4)					
"	Crescent Bay to Ediz Hook	0209									(120)	(20)					
	Regional total			300	500		220	4+	2,015	100	(319)	(69)	300	300	100		4,034
Region	Strait of Juan de Fuca-Inner	03--															
Subregion	Strait of Juan de Fuca--Inner	0301									(50)	(10)					
"	Ediz Hook	0302									(+)	(+)					
"	Port Angeles	0303									(10)						
	Port Angeles Harbor		3				40				+					40	
"	Voice of America	0304									(150)	(150)					
"	Dungeness Spit	0305									(15)	(25)					
"	Dungeness Bay/Harbor	0306									(40)	(+)					
"	Jamestown	0307									(90)						
	Three Crabs Pier		4				22		10							32	

Table 5. (continued)

				SPECIES												
		Region/Subregion Number	Island/Site Number	Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Double-crested Cormorant	Pelagic Cormorant	Black Oystercatcher	Glaucous-winged Gull	Common Murre	Pigeon Guillemot	Marbled Murrelet	Cassin's Auklet	Rhinoceros Auklet	Tufted Puffin	Island/Site Total	Regional Total
Subregion	Sequim Bay	0308									(15)	(1)					
"	Miller Peninsula	0309									(90)	(30)					
"	Protection Island	0310									(560)						
	Protection Island**		5				295	6	4,300		180			17,000	33	21,914	
"	Discovery Bay	0311									(30)	(1)					
"	Quimper Peninsula	0312									(60)	(3)					
"	Whidbey Island	0313									(30)	(10)					
"	Smith Island	0314									(20)						
	Smith and Minor Islands		6				100	6	110		30			600	+	846+	
"	Deception Pass	0315									(15)	(10)					
	Northwest Island		7				5±?									5?	
"	Lopez Island (south shore)	0316									(170)	(30)					
	Buck Island		8					1?	1							1	
	Castle Island		9				1				50					51	
	Colville Island		10			31	115	2	1,000		30				3±?	1.181	
	(island west of Colville Island)		11						40							40	
	Hall Island		12				12	1	350		6					369	
	Long Island		13					8	10							18	
	(island south of Long Island)		14						20							20	
	(island west of Long Island)		15						100							100	
	Mummy Rocks		16					?	25							25	
	Whale Rocks		17					1	5							6	
"	San Juan Island (south shore)	0317									(2)	(3)					
"	Victoria, Vancouver Island	0318									–	–					
	Race Rocks		C23				437	1	417		+					860	
	Regional total					31	1,022	25	6,388		(1,387)	(237)		17,600	33+		25,930

Table 5. (continued)

				SPECIES													
		Region/Subregion Number	Island/Site Number	Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Double-crested Cormorant	Pelagic Cormorant	Black Oystercatcher	Glaucous-winged Gull	Common Murre	Pigeon Guillemot	Marbled Murrelet	Cassin's Auklet	Rhinoceros Auklet	Tufted Puffin	Island/Site Total	Regional Total
Region	Admiralty Inlet	04--															
Subregion	Admiralty Inlet	0401					?				(35)	(10)					
	Regional total						?				(35)	(10)					23
Region	Anacortes to Hale Passage	05--															
Subregion	Bellingham Channel	0501									(80)	(10)					
	Viti Rocks		18				11	1	200		1					213	
	Eliza Rock		19					3			1					4	
	Cone Islands		20								3?					3?	
"	Guemes Channel	0502									(30)	(20)					
"	Fidalgo Bay	0503									(3)	(2)					
"	Padilla Bay	0504									(20)	(30)					
	Swinomish		21						500							500	
"	Samish Bay	0505									(120)	(60)					
"	Bellingham Bay	0506							50		(30)	(25)					
	Chuckanut Rock		22						50		10					60	
"	Hale Passage	0507									(20)	(260)					
	Regional total						11	4	800		(303)	(407)					1,171
Region	Georgia Strait-Eastern	06--															
Subregion	Lummi Bay	0601									(10)	(20)					
"	Cherry Point	0602									(30)	(1)					
"	Birch Bay	0603									(1)	(10)					
"	Semiahmoo Spit	0604									(1)	(5)					
"	Drayton Harbor	0605									+						
	Drayton Harbor		23			10			10							20	
"	Boundary Bay	0606									(40)	(340)					
"	San Juan Islands-										(130)	(30)					
	Northern Tier	0607									50					50	
	Matia Island		24						20		+					20	
	Patos Island		25					1	350		140					491	
	Puffin Island		26								310					310	
	Sucia Island		27														

Table 5. (continued)

		Region/Subregion Number	Island/Site Number	Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Double-crested Cormorant	Pelagic Cormorant	Black Oystercatcher	Glaucous-winged Gull	Common Murre	Pigeon Guillemot	Marbled Murrelet	Cassin's Auklet	Rhinoceros Auklet	Tufted Puffin	Island/Site Total	Regional Total
										SPECIES							
Subregion	Georgia Strait	0608									(60)	(320)					
	Regional total					10		1	380		(1,142)	(726)					1,325
Region	Georgia Strait-Western	07--															
Subregion	Pt. Roberts	0701									(10)	(170)					
	Pt. Roberts		28						20							20	
"	Tsawwassen Bay	0702										(2)					
"	Georgia Strait	0703									(10)	(110)					
	Regional total								20		(20)	(282)					171
Region	Haro Strait	08--															
Subregion	Northern Haro Strait	0801									(150)	(110)					
	Bare Island		29				50	1	120						2	173	
	Cactus Island		30					1			20					21	
	(rock N.E. Cock Island)		31					1								1	
	Satellite Island		32					1			3					4	
	Skipjack Island		33						75		20					95	
	Speiden Island (N. side)		34								50					50	
"	Southern Haro Strait	0802									(30)						
	Regional total						50	4	195		(210)	(110)			2		411
Region	Rosario Strait	09--															
Subregion	Southern Rosario Strait	0901									(50)	(40)					
	Bird Rocks		35			95	15	1	250		7					368	
	Williamson Rocks		36			73	31	1	200		25			?	?	330	
"	Central Rosario Strait	0902									(30)	(2)					
	North Peapod Island		37					1	100		2					103	
	Middle Peapod Island		38						+							+	
	Southern Peapod Island		39					1	130		2					133	
	Pointer Island		40					1?	20		4					24	

Table 5. (continued)

				SPECIES													
		Region/Subregion Number	Island/Site Number	Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Double-crested Cormorant	Pelagic Cormorant	Black Oystercatcher	Glaucous-winged Gull	Common Murre	Pigeon Guillemot	Marbled Murrelet	Cassin's Auklet	Rhinoceros Auklet	Tufted Puffin	Island/Site Total	Regional Total
Subregion	Northern Rosario Strait	0903									(40)	(10)					
	Lummi Island		41								+					+	
	Lummi Rocks		42						10							10	
	South Sister Island		43			2	11	1	130							144	
	Middle Sister Island		44					1	20							21	
	North Sister Island		45					2	410		3					415	
	Regional total					170	57	8	1,270+		(134)	(52)		?	?		1,598
Region	San Juan Islands-Northern Waters	10--															
Subregion	President Channel	1001									(50)	(10)					
	Flat Top Island		46					1			20					21	
	Gull Rock		47						100							100	
	Waldron Island		48								2					2	
	White Rock		49					+	75		10					85+	
"	Northern Areas	1002									(5)	(2)					
	Regional total							1+	175		(69)	(12)					217
Region	San Juan Islands-Interior Channels and Passages	11--															
Subregion	Speiden Channel	1101									(20)						
	Sentinel Island		50								+					+	
"	Northern San Juan Channel	1102									(1)	(2)					
"	Southern San Juan Channel	1103									(4)						
	Goose Island		51						60							60	
"	Wasp Pass	1104									(3)	(2)					
	Low Island		52					1	?		2					3	
"	Upright Channel	1105										(3)					
"	Harney Channel	1106									(10)	(10)					
	Willow Island		53						4		4					8	

Table 5. (continued)

				SPECIES													
		Region/Subregion Number	Island/Site Number	Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Double-crested Cormorant	Pelagic Cormorant	Black Oystercatcher	Glaucous-winged Gull	Common Murre	Pigeon Guillemot	Marbled Murrelet	Cassin's Auklet	Rhinoceros Auklet	Tufted Puffin	Island/Site Total	Regional Total
Subregion	Obstruction Pass	1107									(2)	(2)					
"	Thatcher Pass	1108									(1)	(+)					
	Regional total							1	64		(42)	(19+)					96
Region	San Juan Islands-Interior Bays	12--															
Subregion	Mosquito/Roche Complex	1201									(40)						
"	Friday Harbor	1202															
"	Griffin Bay	1203										(15)					
"	Fisherman Bay	1205										(0)					
"	Swiftsure/Shoal Bays	1206									(10)	(5)					
	Flower Island		54						33		10					43	
"	Deer Harbor	1207									(10)	(2)					
"	West Sound	1208									(2)						
"	East Sound	1209									(1)						
"	Lopez Sound	1210									(20)	(5)					
	Small Island		55						35		+					35+	
	Regional total								68		(93)	(27)					129
Region	Canadian Waters	13--															
Subregion	Active Pass	1301									(4)	(+)					
	Galiano Island (east end)		C1								15±					15	
	Red Islets		C2					1	1?							2	
"	Canadian Gulf-Islands	1302									–	–					
	Provost Island		C3				17		2		?					19	
	Channel Islands		C4					1?	1							1	
	Belle Chain Islets		C5					+?	29							29	
	Saturna Island		C6								2±					2	
	Pine Island		C7					2?	4±							6	
	Saturna Island		C8				47		7							54	
	Java Islets		C9					2	374		4±					380	
	Saturna Island		C10								7±					7	
	North Pender Island		C11								2±					2	
	South Pender Island		C12								4±					4	
	North Pender Island		C13								17±					17	
	Jackson Rock		C14					1								1	
	Arbutus Island		C15					1	39							40	
	Moresby Island		C16					1								1	
	Imrie Island		C17					1	315		1					317	

Table 5. (continued)

				SPECIES													
		Region/Subregion Number	Island/Site Number	Fork-tailed Storm-Petrel	Leach's Storm-Petrel	Double-crested Cormorant	Pelagic Cormorant	Black Oystercatcher	Glaucous-winged Gull	Common Murre	Pigeon Guillemot	Marbled Murrelet	Cassin's Auklet	Rhinoceros Auklet	Tufted Puffin	Island/Site Total	Regional Total
Subregion	Reay Island		C18					?	6							6	
	Grieg Island		C19						40		?					40	
	Dock Island		C20						35		2?					35	
	Rubly Island		C21					2	+							2	
	(other minor colories)								95							95	
"	Sidney Approach	1303									(110)	(3)					
	Mandarte Island		C22			840	501	6+	1,666		70				2	3,085	
	Regional total					840	565	15+	2,614		122	(3+)			2		4,160
Total Individuals***											3,998	1,990					
Total Pairs				300	500	1,051	1,930	63	13,989	100	1,999	995	300	17,900	137		= 39,264
Percent of Total				<1	1.3	2.7	4.9	<1	35.6	<1	5.1	2.5	<1	45.6	<1		
Total Pairs U.S. Waters				300	500	211	928	47+	10,958	100	1,877	993	300	17,900	135		= 34,249
Percent of Total				<1	1	<1	3	<1	32	<1	5	3	1	52	<1		
Total Pairs Canadian Waters				0	0	840	1,002	16+	3,031	0	122	2+	0	0	2		= 5,015
Percent of Total				0	0	17	20	<1	60	0	2	<1	0	0	<1		

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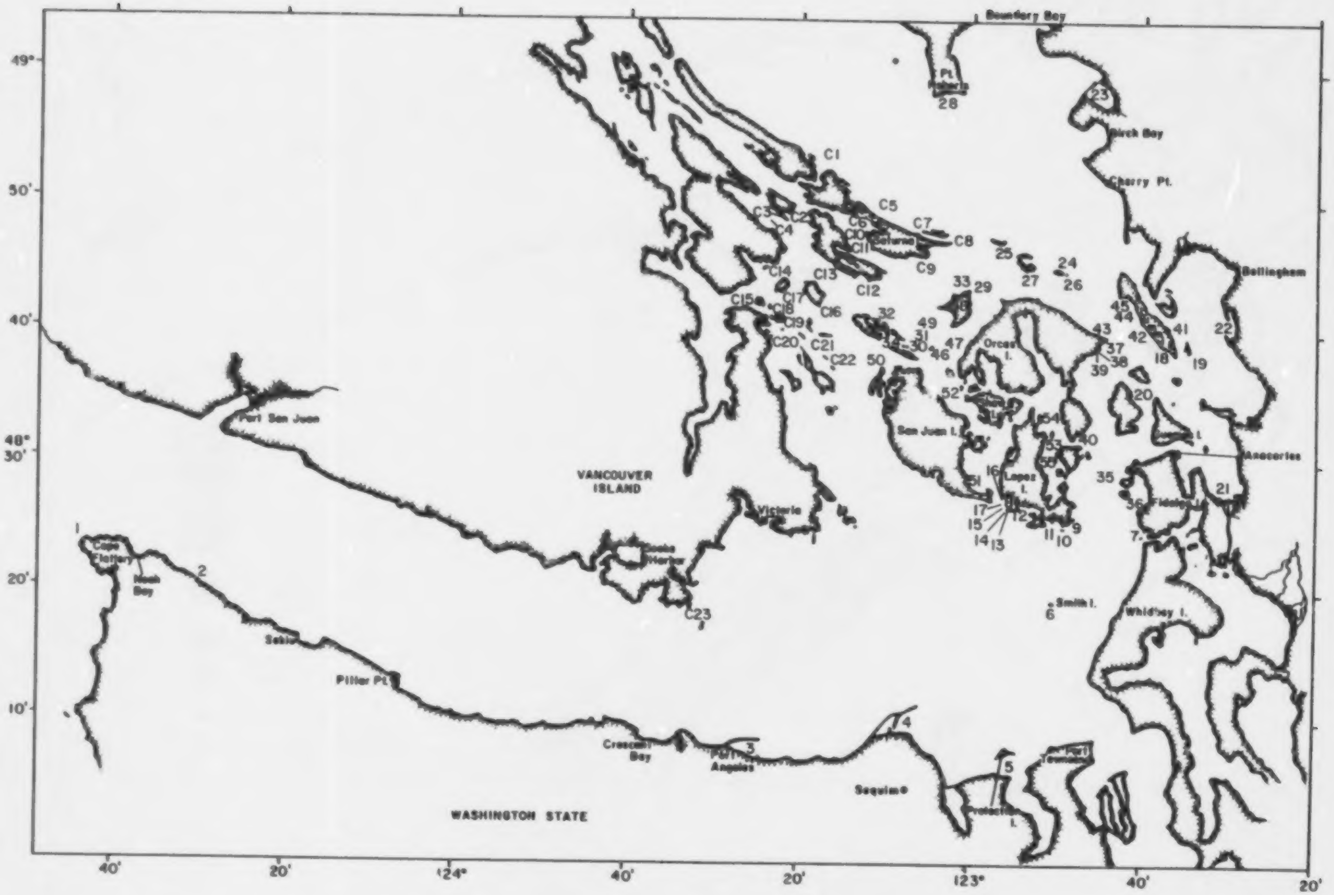
*Estimates represent the most accurate information available. Some areas were censused in 1978, whereas others were censused in 1979.

**1980 population estimates (in pairs) by Washington Department of Game: Double-crested Cormorant 8, Pelagic Cormorant 296, Black Oystercatcher 13, Glaucous-winged Gull 4744, Pigeon Guillemot 302+, Tufted Puffin 38.

***Since the nests of Pigeon Guillemots and Marbled Murrelets are difficult to find, we recorded the total number of individual birds observed rather than present the number of pairs.


49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Anacortes
Fidalgo I.
Whidbey I.
Smith I.
Orcas I.
San Juan I.
Lopez I.
Saturna
VANCOUVER ISLAND
Victoria
Port San Juan
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE
1
2
3
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51
52
53
54
55
C1
C2
C3
C4
C5
C6
C7
C8
C9
C10
C11
C12
C13
C14
C15
C16
C17
C18
C19
C20
C21
C22
C23

Figure 7. Map of numbered breeding bird colony sites.

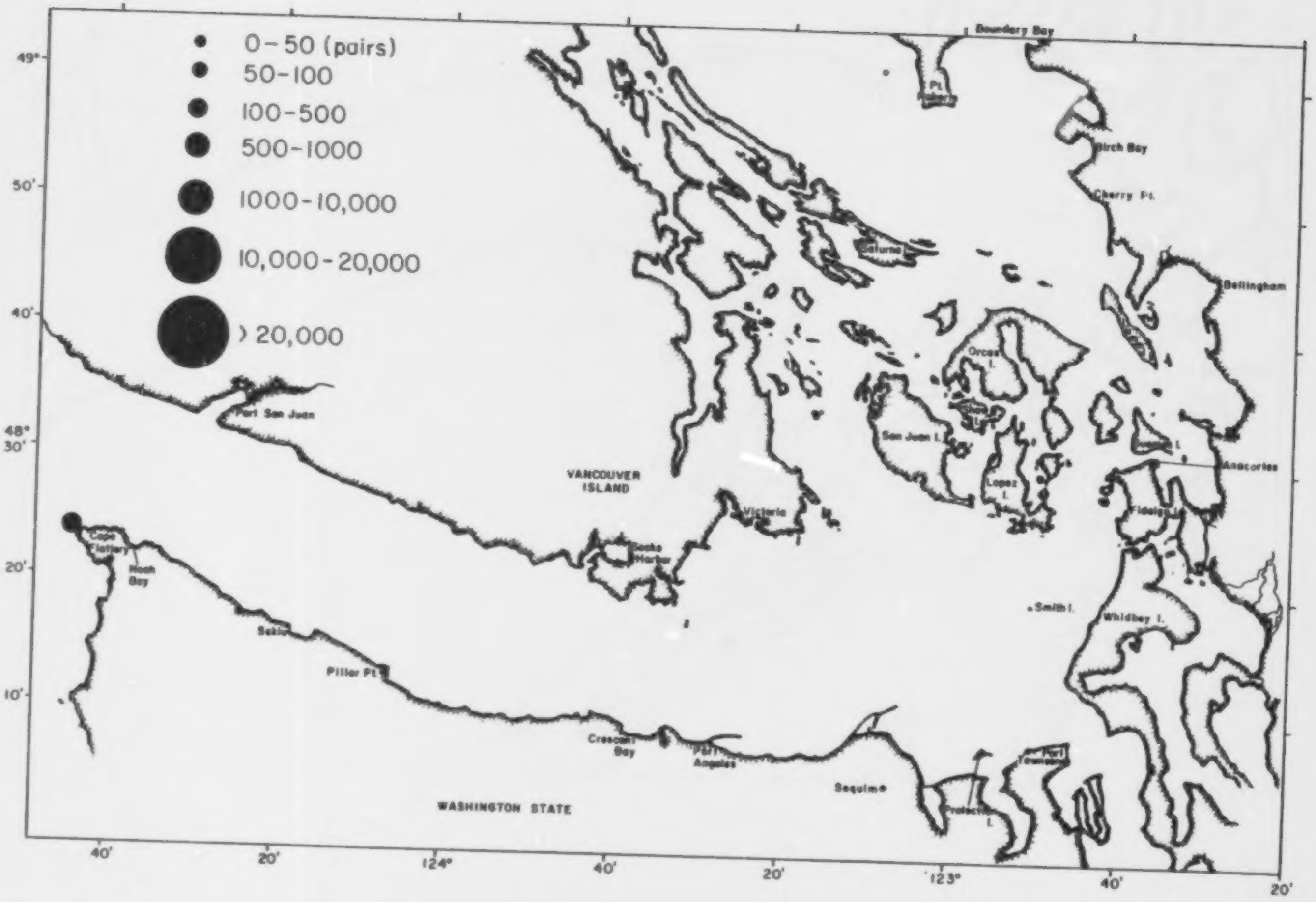

0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna I.
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE

Figure 8. Map of the breeding sites of the Fork-tailed Storm-Petrel.

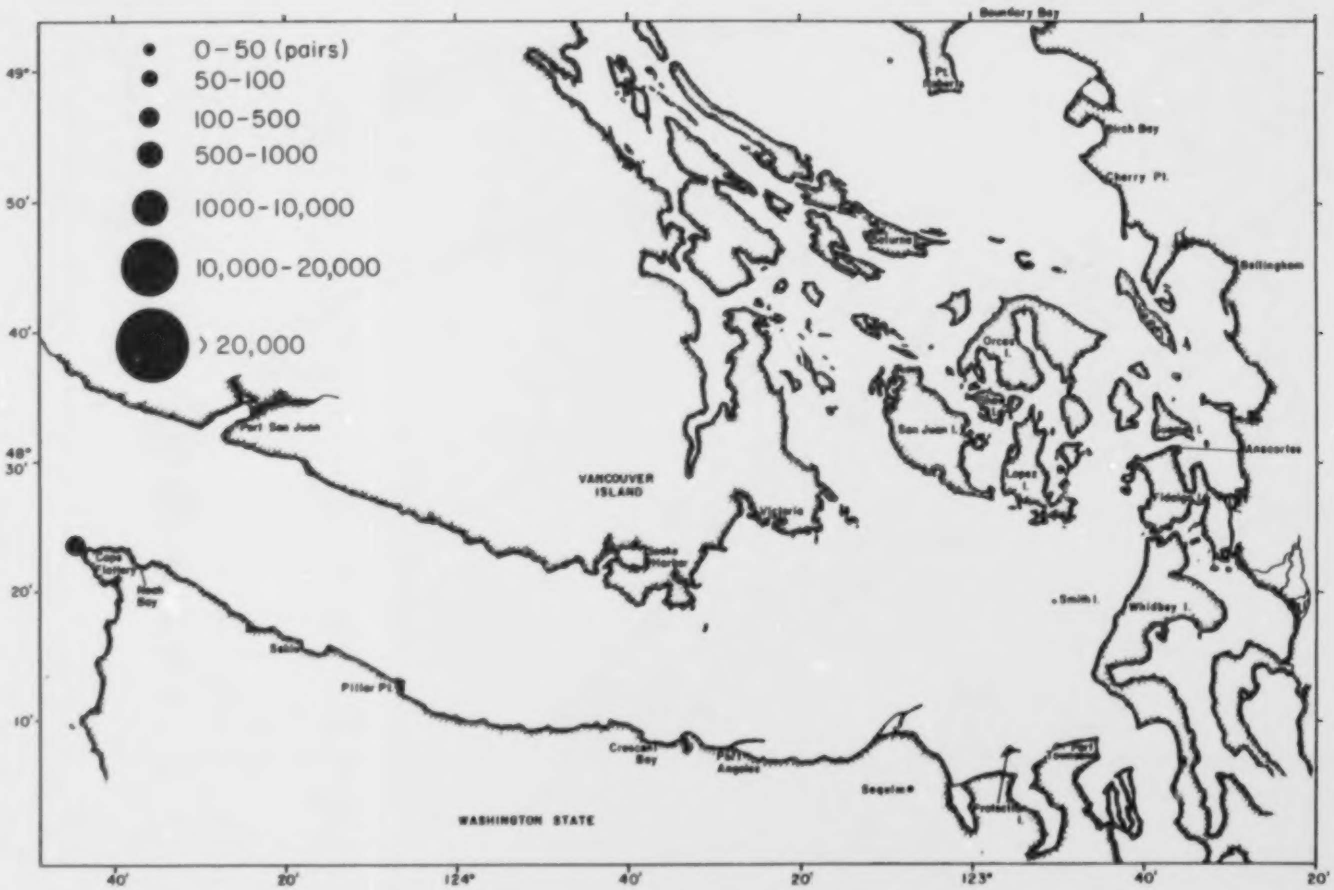

0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt.
Birch Bay
Cherry Pt.
Bellingham
Orcas I.
San Juan I.
Lopez I.
Anacortes
Smith I.
Whidbey I.
VANCOUVER ISLAND
Port San Juan
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE

Figure 9. Map of the breeding sites of the Leach's Storm-Petrel.

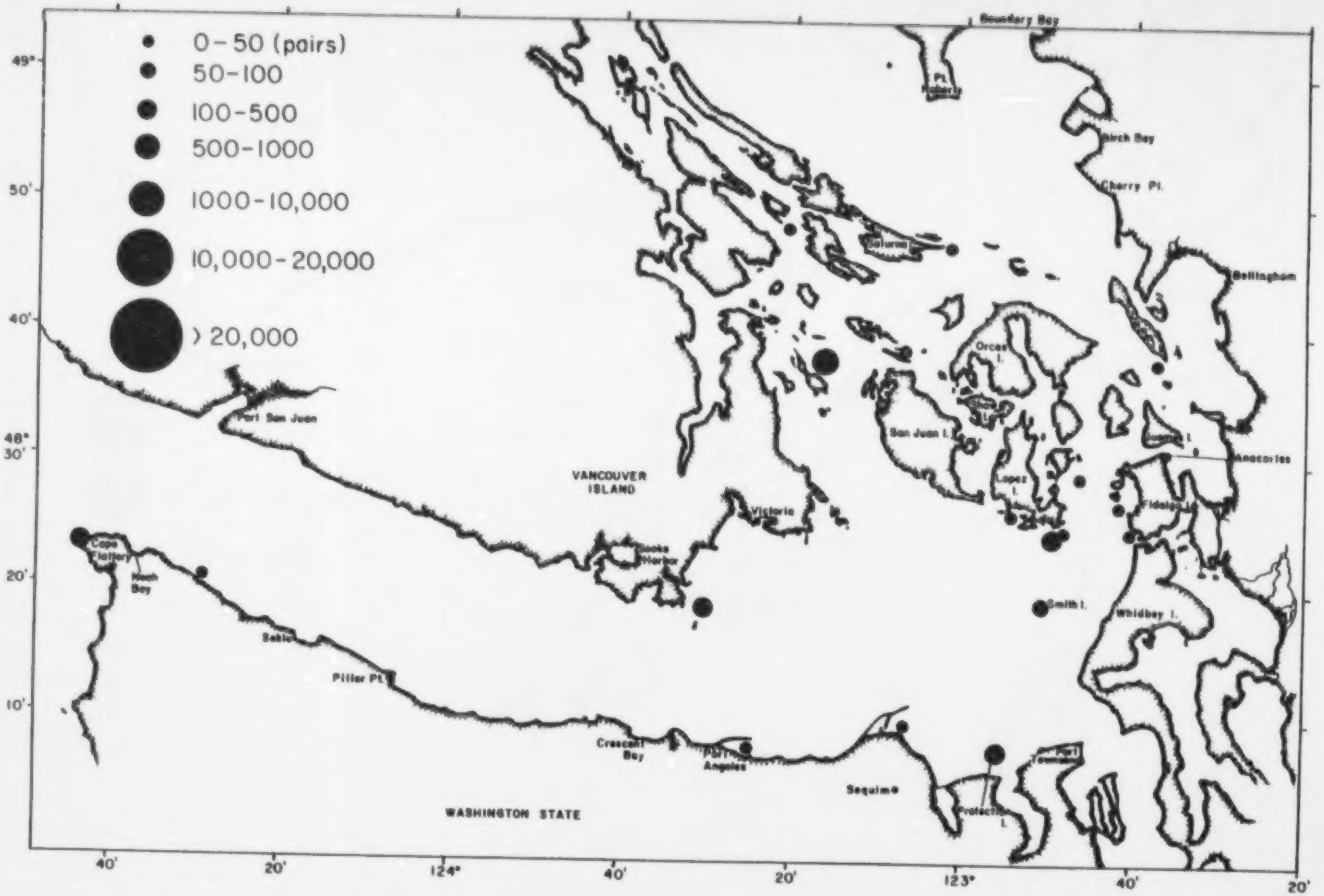
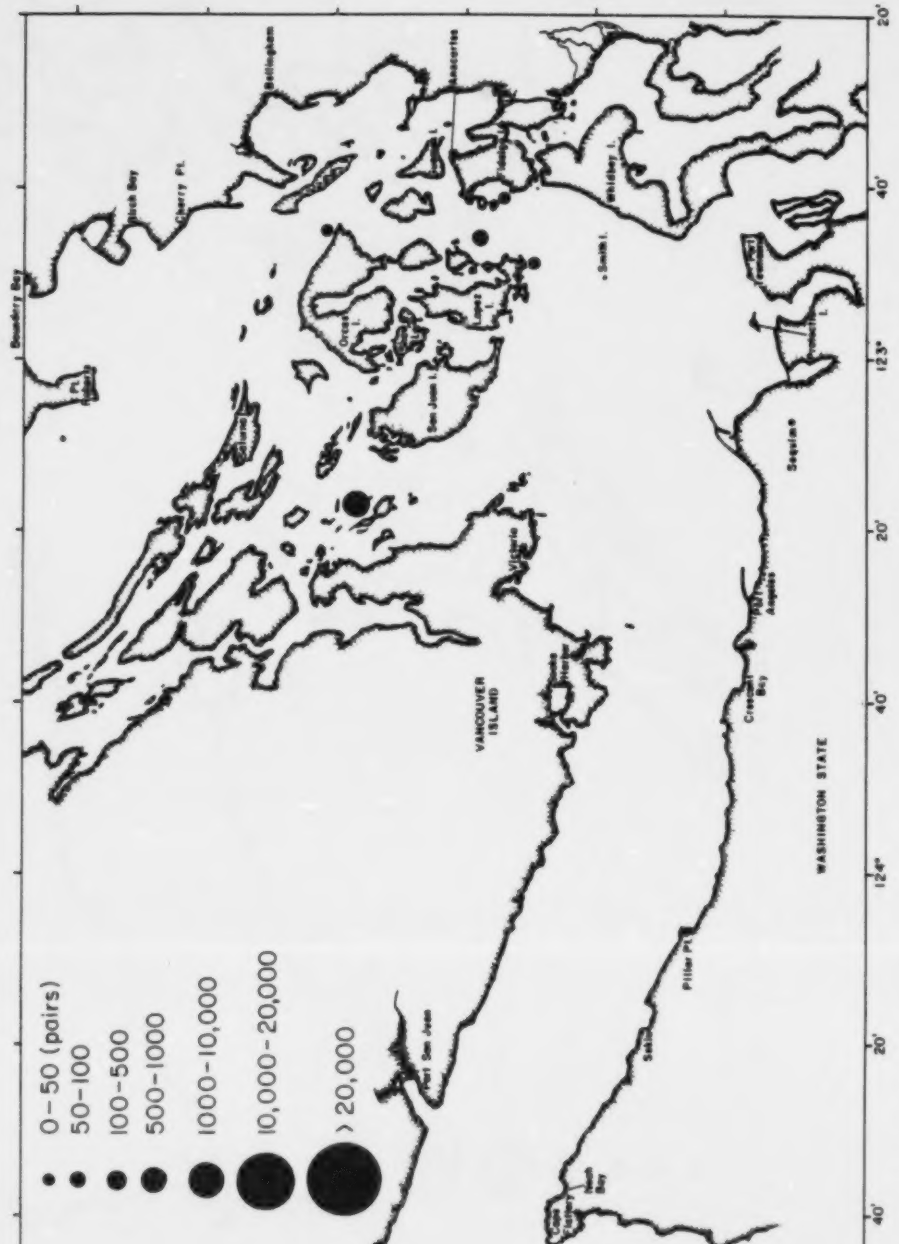

0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Galiano
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo
Smith I.
Whidbey I.
Port Townsend
Protection I.
Sequim
Port Angeles
Crescent Bay
Pillar Pt.
Sekiu
Neah Bay
Cape Flattery
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
WASHINGTON STATE
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 10. Map of the breeding sites of the Pelagic Cormorant.



0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
Boundary Bay
Birch Bay
Cherry Pt.
Bellingham
Anacortes
Whidbey I.
Smith I.
Orcas I.
Lopez I.
San Juan I.
Victoria
Sequim
Port Angeles
Crescent Bay
VANCOUVER ISLAND
WASHINGTON STATE
Pillar Pt.
Sekiu
Port San Juan
Cape Flattery
Neah Bay
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 11. Map of the breeding sites of the Double-crested Cormorant.

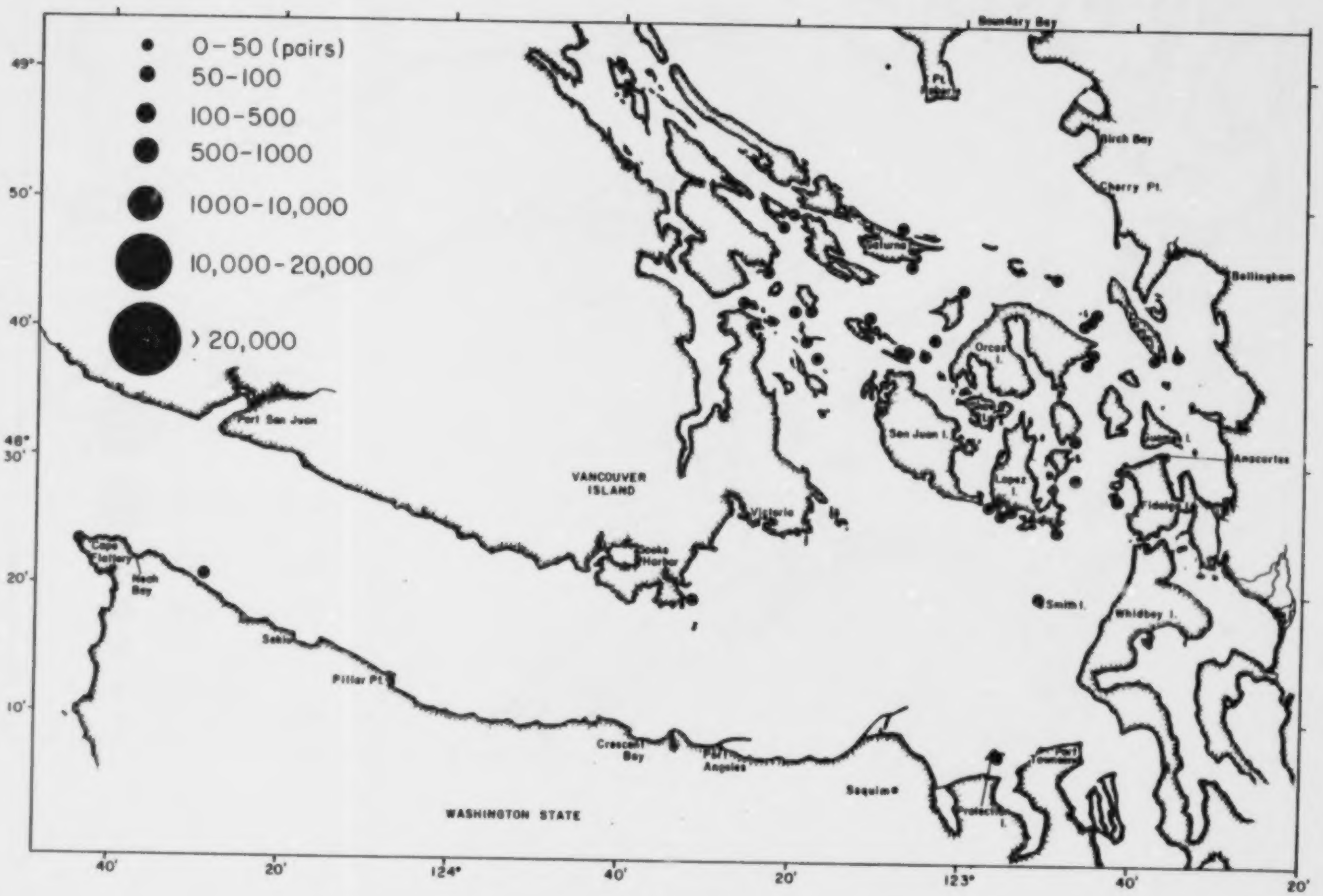
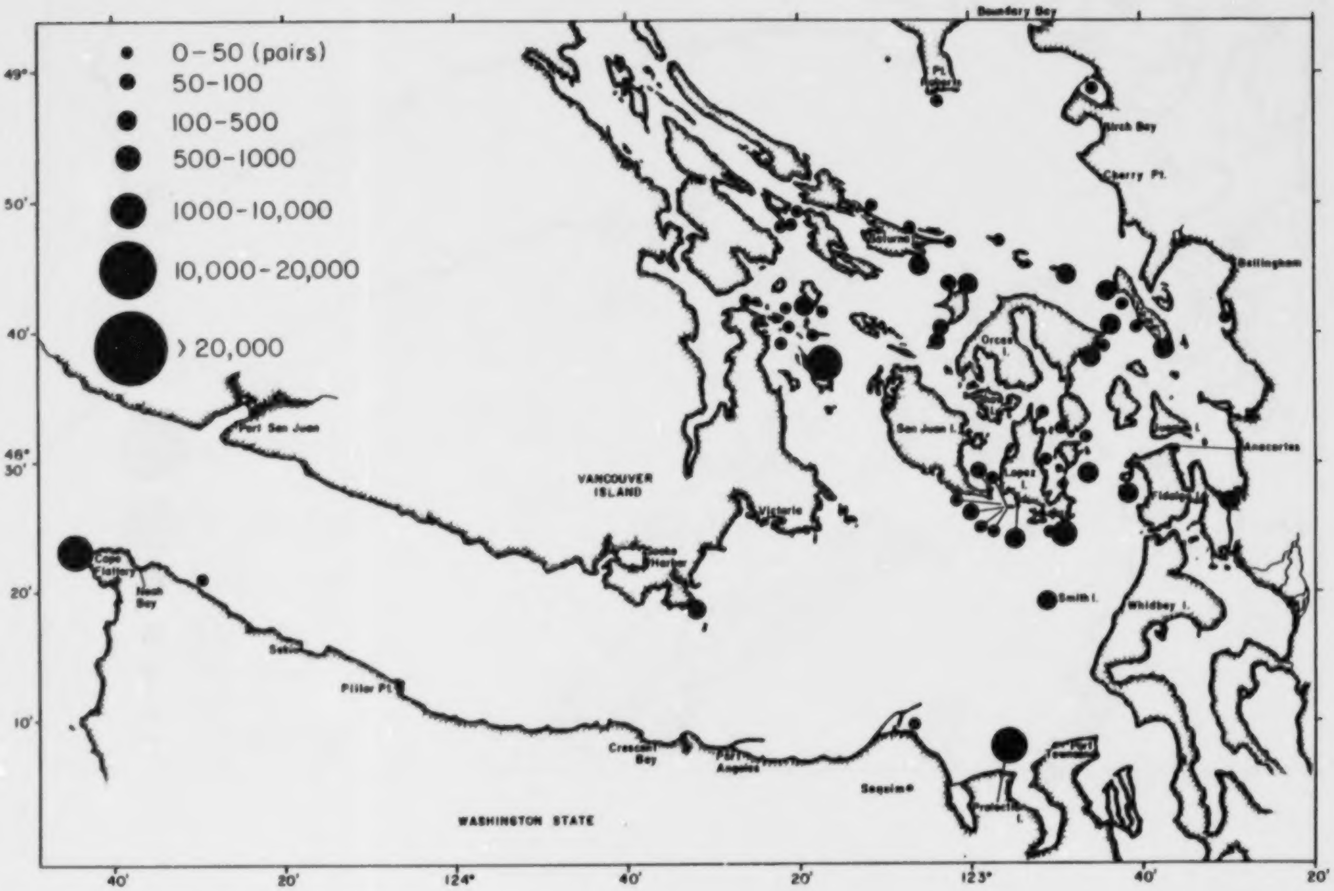

0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
) 20,000
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Galiano
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo
Smith I.
Whidbey I.
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 12. Map of the breeding sites of the Black Oystercatcher.



0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port Townsend
Protection I.
Sequim
Port Angeles
Crescent Bay
Pillar Pt.
Sekiu
Neah Bay
Cape Flattery
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
WASHINGTON STATE
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 13. Map of the breeding sites of the Glaucous-winged Gull.

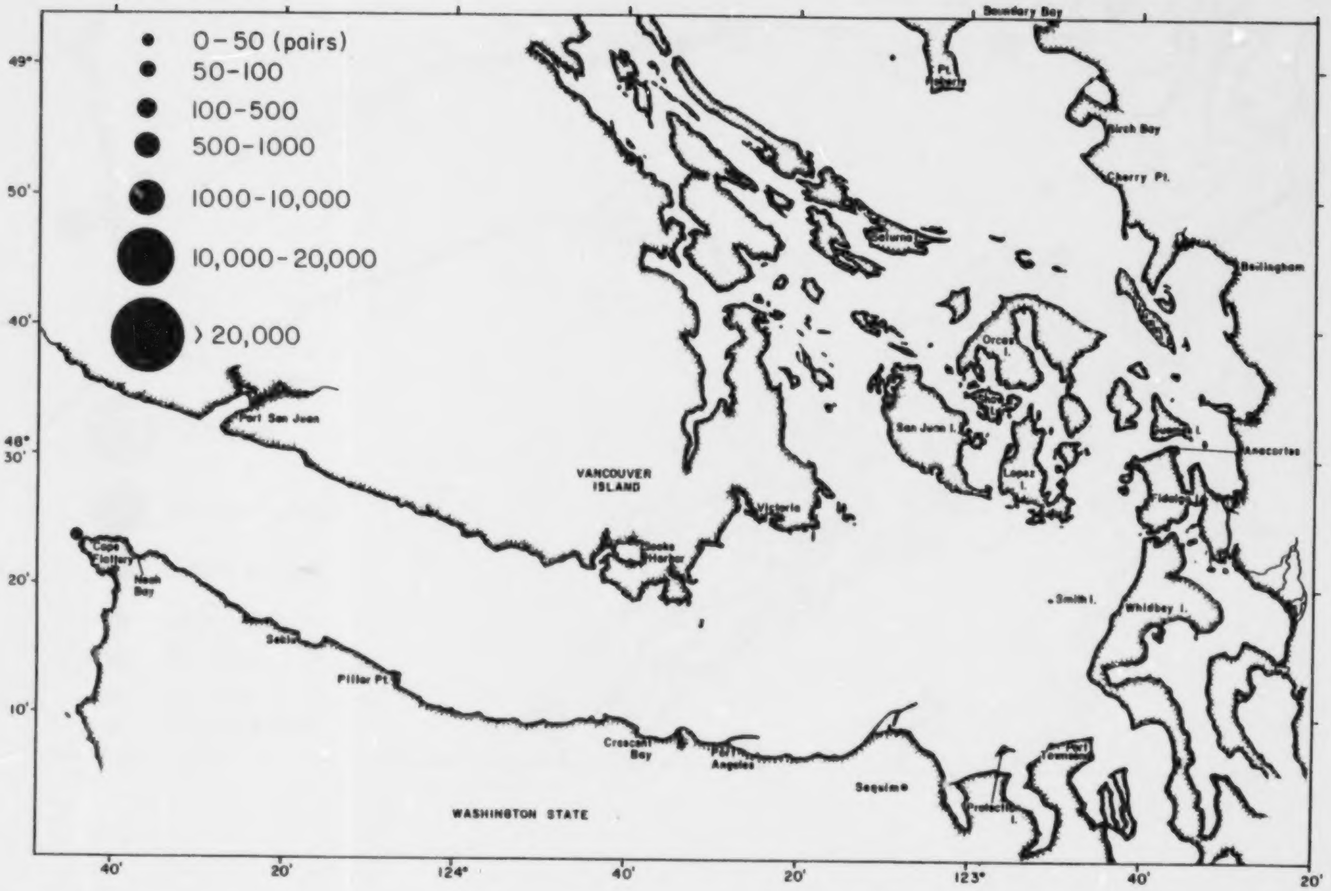

0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Galiano
Bellingham
Orcas I.
Shaw I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE

Figure 14. Map of the breeding sites of the Common Murre.

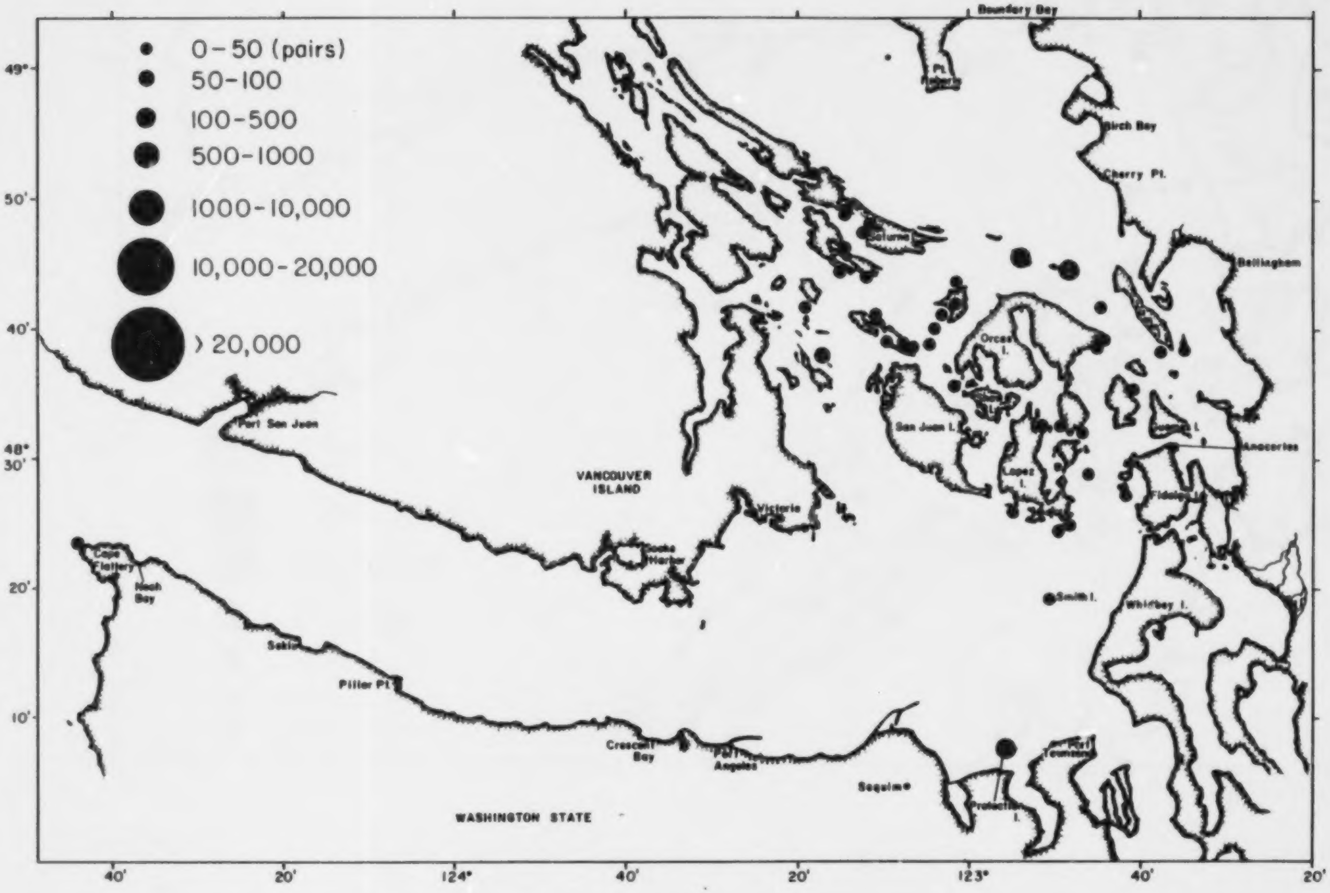
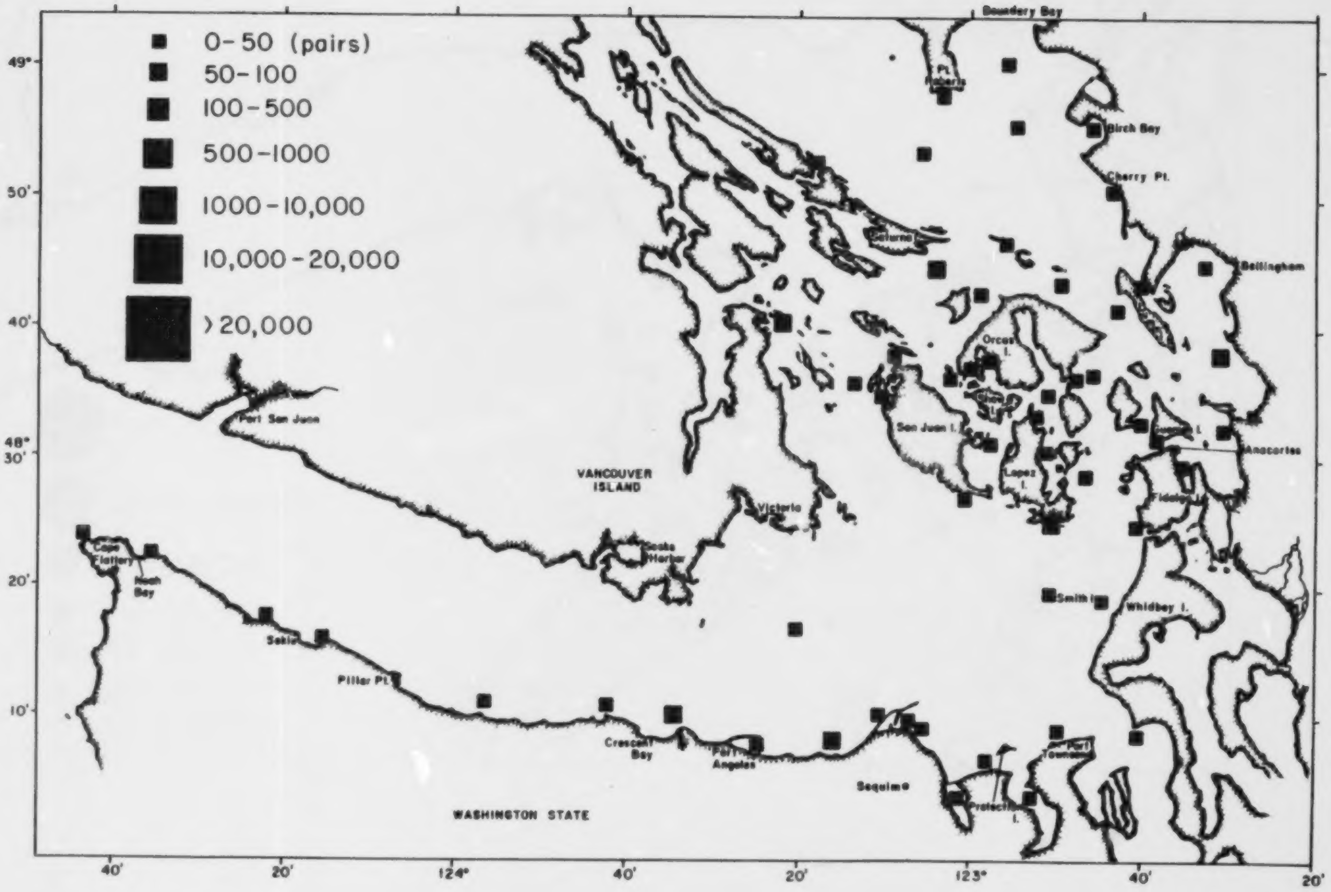
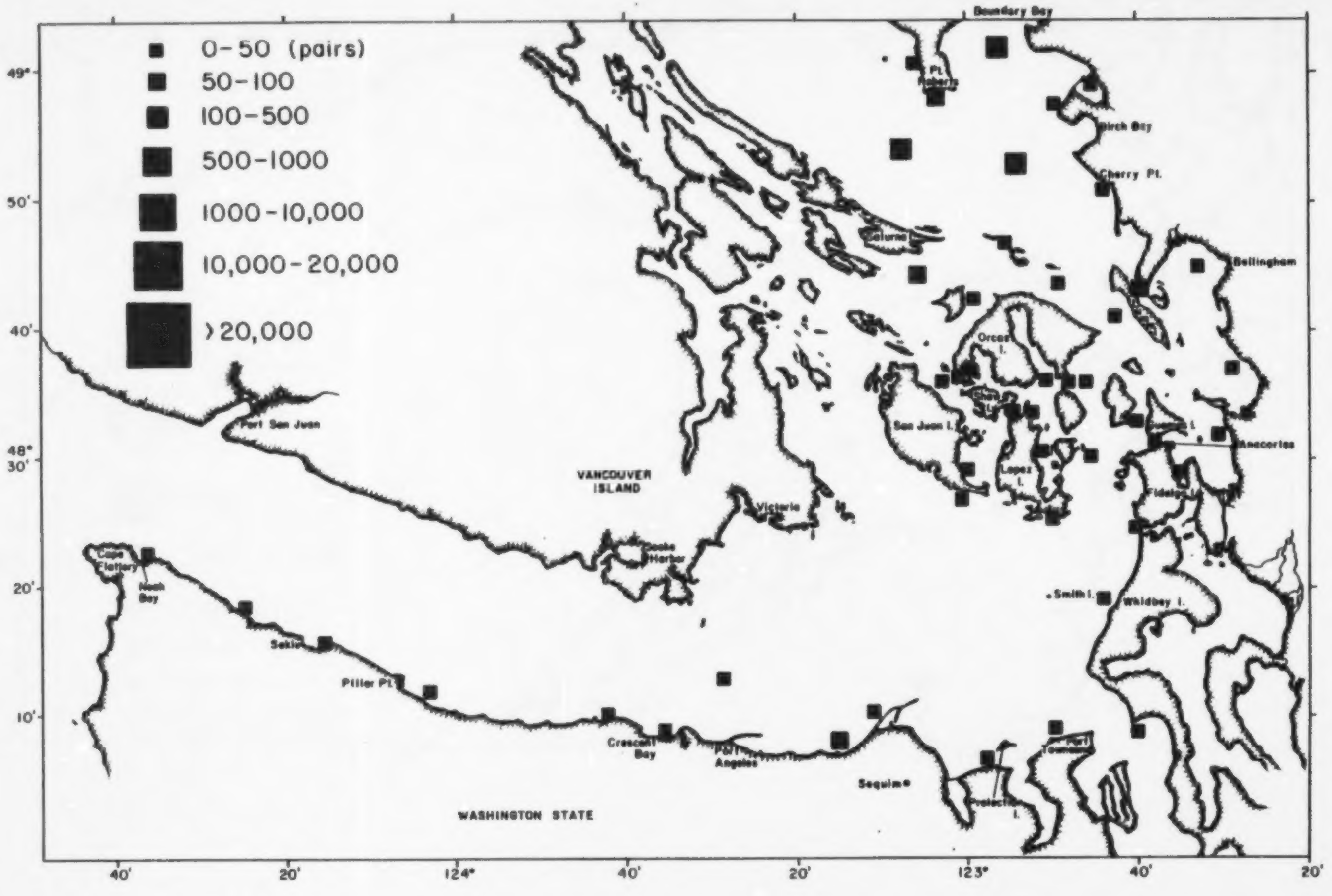

0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port Townsend
Protection I.
Sequim
Port Angeles
Crescent Bay
Pillar Pt.
Sekiu
Neah Bay
Cape Flattery
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
WASHINGTON STATE

Figure 15. Map of the breeding sites of the Pigeon Guillemot as determined by on-site inspection.



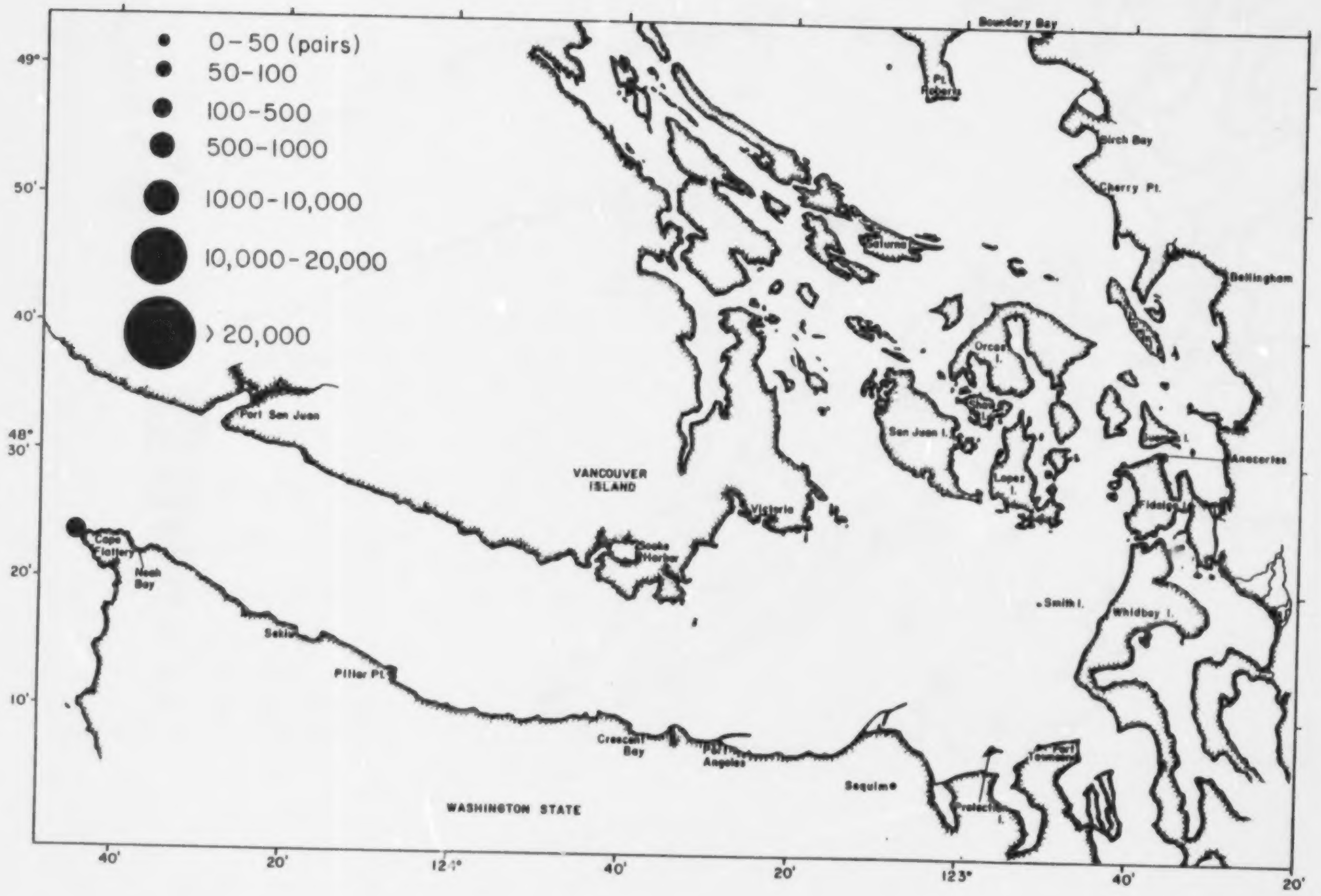
0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
>20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE

Figure 16. Map of the projected total number of breeding pairs of the Pigeon Guillemots in each subregion as determined through standard censuses.



0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
>20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Galiano
Orcas I.
Shaw I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Victoria
Sooke Harbor
VANCOUVER ISLAND
Port San Juan
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE

Figure 17. Map of the projected total number of breeding pairs of the Marbled Murrelet in each subregion as determined through standard censuses.



0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
> 20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Saturna
Bellingham
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Victoria
VANCOUVER ISLAND
Port San Juan
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
Smith I.
Whidbey I.
WASHINGTON STATE

Figure 18. Map of the breeding sites of the Cassin's Auklet.

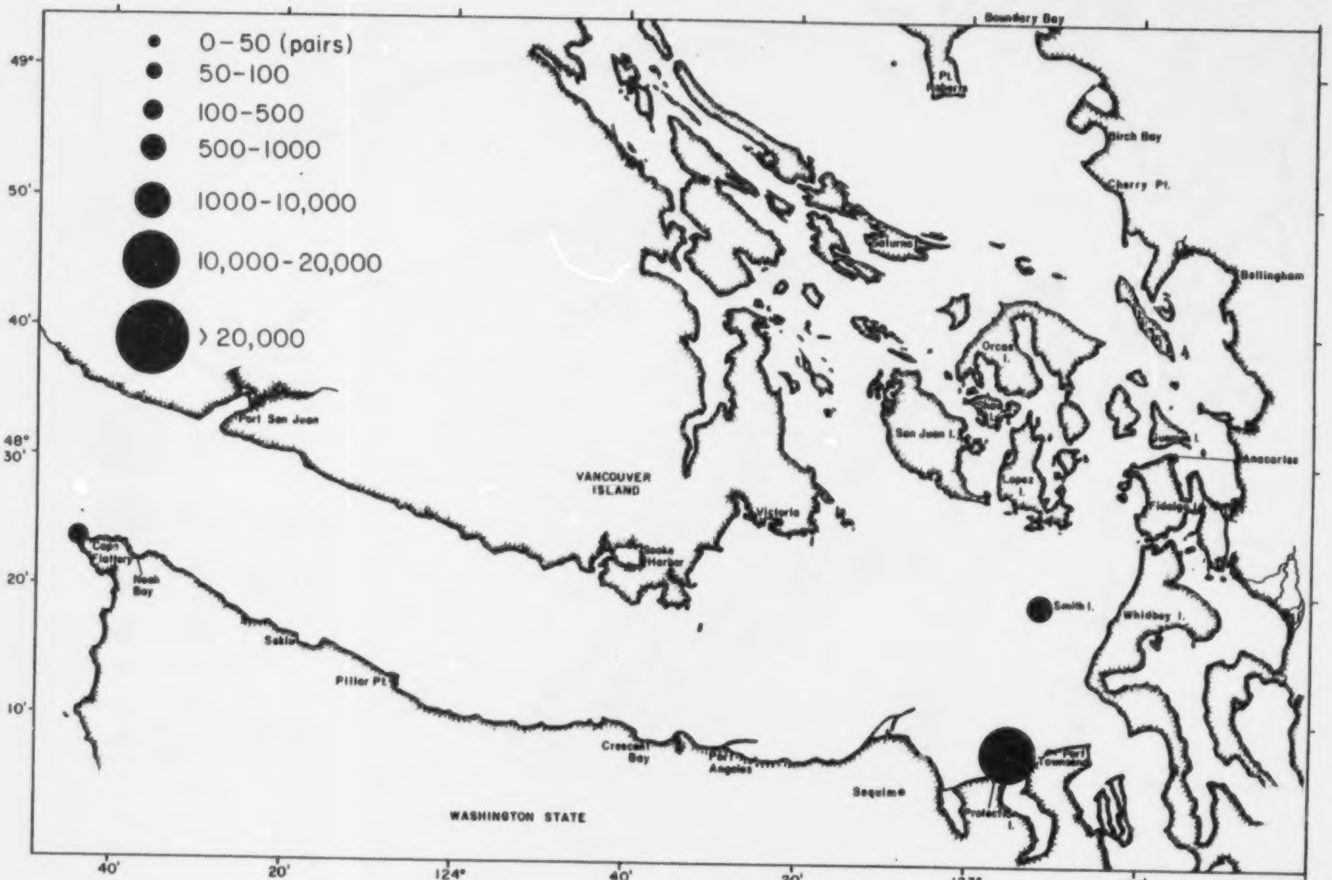
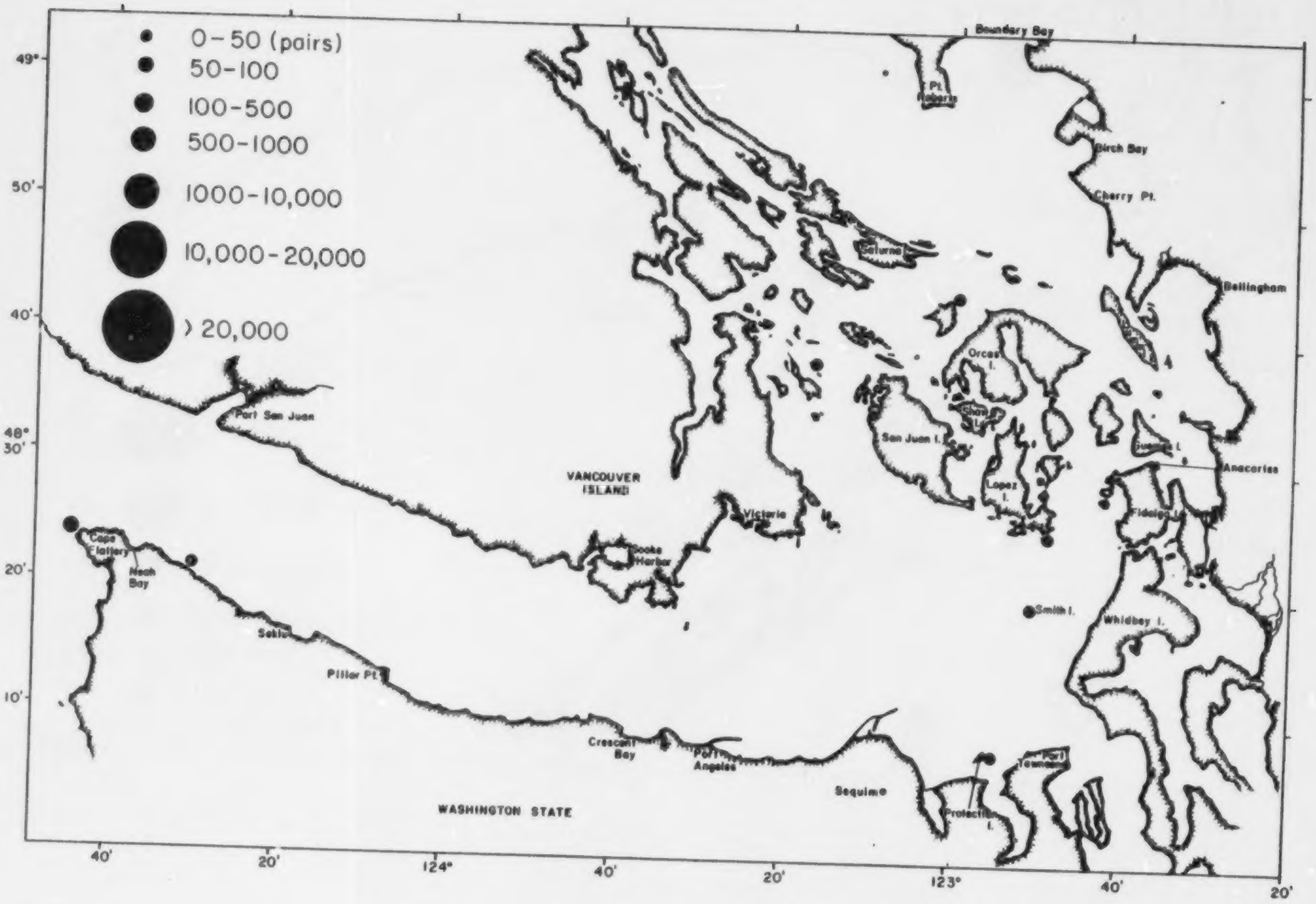

0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
› 20,000
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna
Orcas I.
San Juan I.
Lopez I.
Anacortes
Smith I.
Whidbey I.
Port Townsend
Protection I.
Sequim
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Piller Pt.
Crescent Bay
Port Angeles
WASHINGTON STATE

Figure 19. Map of the breeding sites of the Rhinoceros Auklet.


0-50 (pairs)
50-100
100-500
500-1000
1000-10,000
10,000-20,000
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49°
50'
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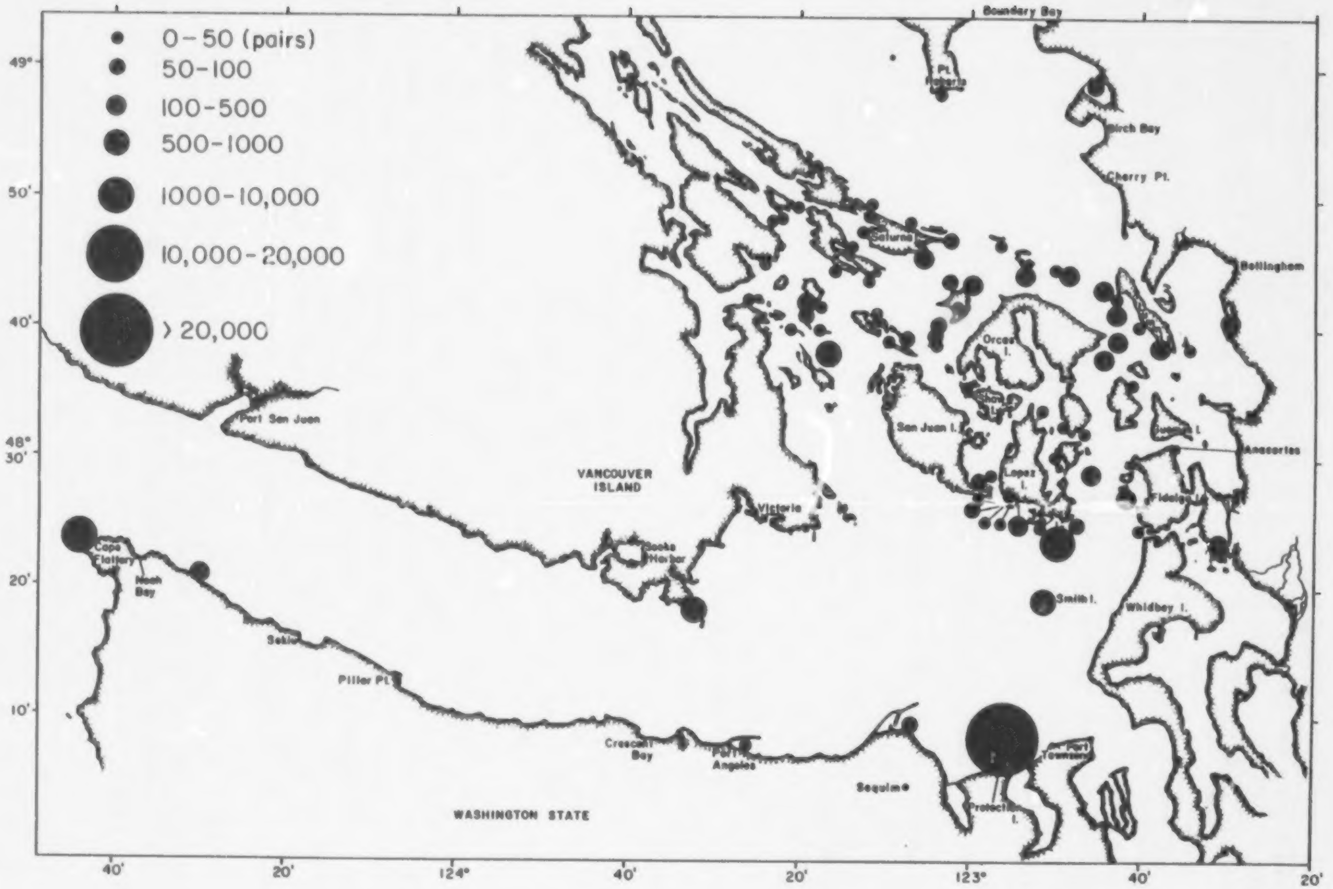
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
VANCOUVER ISLAND
Victoria
Sooke Harbor
Port San Juan
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE

Figure 20. Map of the breeding sites of the Tufted Puffin.


0-50 (pairs)
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20'
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124°
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123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna
Orcas I.
Shaw I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Port Townsend
Protection I.
WASHINGTON STATE

Figure 21. Map of the breeding sites of all species.

colonies on the outer coast of Washington, containing in addition to the species found throughout the study area, Storm-Petrels, Cassin's Auklet and Common Murre: species of the coastal ocean, continental shelf or pelagic waters.

A small breeding colony on Seal and Sail Rocks was typical of some of the colonies in the study area with breeding Pelagic Cormorants, Black Oystercatchers, Glaucous-winged Gulls, and Pigeon Guillemots. This colony also contained one of the few sites with nesting Tufted Puffins in the study area.

No other major colony sites were found in this region, although Pigeon Guillemots and Marbled Murrelets were present in generally low numbers along the entire Olympic Peninsula shoreline of this region. The shoreline of Vancouver Island apparently supports few breeding birds as determined by this study and surveys conducted by the British Columbia Provincial Museum (R.W. Campbell, pers. comm.).

3. Region 3. Strait of Juan de Fuca-Inner

Within this region breeding birds were concentrated on Protection Island, Smith and Minor Islands, and along the south shore of Lopez Island. Other colonies were found on an abandoned pier in the Jamestown subregion, and on Race Rocks near Victoria (Vancouver Island). This was clearly the most important region of the entire study area for breeding birds.

Of all the inland marine waters of Washington and associated Canadian waters, Protection Island was the single most important nesting site, having about 22,000 nesting pairs. It alone contained over 64% of all the known nesting pairs of marine birds in the study area and, including the adjacent Canadian waters, this site accounted for 56% of all known nesting marine birds. Protection Island was the nesting site for 95% of all known nesting Rhinoceros Auklets in the study area: 17,000 of 17,900 pairs. This site probably contains over 50% of all known breeding Rhinoceros Auklets in the contiguous United States. The island was the site of the largest Glaucous-winged Gull colony (4,300 pairs) in the study area and the adjacent Canadian waters, representing fully 39% of the species' numbers in the study area, and 31% of all known breeding birds in the study area and adjacent Canadian waters combined. Significant numbers of Pelagic Cormorants (295 pairs; 32% of American birds or 29% of American and adjacent Canadian waters' birds) and Pigeon Guillemots (180+ pairs) nested on Protection Island. The Tufted Puffin nested on Protection Island in small numbers, 33 pairs, but even this small number represented one-fourth (24%) of all known nesting pairs of this species in interior Washington and adjacent Canadian waters.

Smith and Minor Islands were the sites for about 850 pairs of birds, including 600 pairs of Rhinoceros Auklets, 100 pairs of Pelagic Cormorants and a small number of Tufted Puffins (1-3 pairs). Minor Island had approximately 100 pairs of Glaucous-winged Gulls nesting on it.

There were several nesting sites along the south shore of Lopez Island, the most important being Colville Island (1,200 pairs) and Hall Island (370 pairs). In total about 1,800 pairs of marine birds nested in this subregion and of that total the majority (about 1,500 pairs; nearly 80%) were Glaucous-winged Gulls. Colville Island was the site of nesting Pelagic Cormorants (80 pairs in 1978, 115 pairs in 1979) and Double-crested Cormorants (50 pairs in 1978, 31 pairs in 1979) and they together represented somewhat less than 10% of the breeding Cormorants in the study area. Population fluctuations are typical of Cormorants. Three pairs of Tufted Puffins probably nested on Colville Island.

Small Pelagic Cormorant colonies were located on an abandoned pier at Jamestown (22 pairs) and on pilings in Port Angeles harbor (40 pairs).

In Canadian waters along the south shore of Vancouver Island there were 437 pairs of Pelagic Cormorants on Race Rocks (Campbell 1979). This nesting concentration of Cormorants is larger than any in Washington.

4. Region 4. Admiralty Inlet

There were no breeding colonies located in this subregion. There were, however, scattered pairs of Pigeon Guillemots and Marbled Murrelets along the shoreline.

5. Region 5. Anacortes to Hale Passage

There were two important nesting sites in this region, one on Viti Rocks and the other on dredge-spoil islands ("Swinomish") at the southern end of Padilla Bay. The former site had 80 pairs of Pelagic Cormorants, 30 pairs of Double-crested Cormorants and 390 pairs of Glaucous-winged Gulls in 1978. However, our 1979 counts revealed only 11 pairs of Pelagic Cormorants and one pair of Double-crested Cormorants, again an example of the yearly fluctuation in the numbers of cormorants at a nesting site. The Swinomish colony site, used by about 500 pairs, was made up of nesting Glaucous-winged Gulls (see also Peters et al. 1978). Other species nesting in this region were not numerous. Scattered pairs of Pigeon Guillemots and Marbled Murrelets were found throughout the region.

6. Region 6. Georgia Strait-Eastern

Puffin Island had the only sizable nesting colony in this region, and it contained about 490 pairs of breeding birds. Of this total, 350 pairs were Glaucous-winged Gulls and 140 pairs were Pigeon Guillemots. In Drayton Harbor about 10 pairs of Double-crested Cormorants nested on pilings and concrete rubble. Pigeon Guillemots were scattered throughout the region with a noticeable concentration of this species on Sucia Island (310 pairs). Marbled Murrelets apparently nested throughout the region.

7. Region 7. Georgia Strait-Western

There were only a few sites available for nesting in this region. The only colony consisted of about 20 pairs of Glaucous-winged Gulls nesting on Pt. Roberts. Canadian islands and their shorelines bordering this region are discussed below in the accounts of Region 13. Pigeon Guillemots and Marbled Murrelets were observed during nesting seasons in this region.

8. Region 8. Haro Strait

Only Bare and Skipjack Islands contained any numbers of breeding birds in this region. Bare Island was the nesting site of 50 Pelagic Cormorants and apparently two Tufted Puffins. Skipjack Island had 20 pairs of Pigeon Guillemots, and both sites had nesting Glaucous-winged Gulls. There were many scattered pairs of Pigeon Guillemots and Marbled Murrelets found during nesting seasons in the region.

9. Region 9. Rosario Strait

There were nearly 1,700 nesting pairs of marine birds on nine islands in Rosario Strait. This was about five percent of all nesting birds in the study area. Of this total, Glaucous-winged Gulls comprised about 75%. Bird Rocks and Williamson Rocks each had important colonies of breeding Double-crested and Pelagic Cormorants. Glaucous-winged Gulls were found nesting on at least eight islands. Pigeon Guillemots and Marbled Murrelets were found throughout the region during the nesting season.

10. Region 10. San Juan Islands, Northern Waters

Only three islands had any numbers of breeding birds: Flattop Island, Gull Rock and White Rock. Glaucous-winged Gulls were the major species on these small islands. Several pairs of Pigeon Guillemots nested in the region.

11. Region 11. San Juan Islands, Interior Channels and Passages

Only one site, Goose Island, contained any numbers of birds; and it was used by about 60 pairs of Glaucous-winged Gulls. Nesting Pigeon Guillemots and pairs of Marbled Murrelets were scattered through this region.

12. Region 12. San Juan Islands, Interior Bays

There were only two colony sites in this region, one on Flower Island (33 pairs of Glaucous-winged Gulls) and the other on Small Island (35 pairs of Glaucous-winged Gulls). There were a few scattered pairs of nesting Pigeon Guillemots, and Marbled Murrelets were present during the nesting season.

13. Region 13. Canadian Waters

There were eight islands with numbers of nesting Glaucous-winged Gulls, including sizable colonies on the Java Islets (374 pairs), Imrie Island (315 pairs) and Mandarte Island (about 1,700 pairs). Pelagic Cormorants were found nesting on Prevost Island (17 pairs), Saturna Island (47 pairs) and Mandarte Island (500 pairs). Double-crested Cormorants were found nesting only on Mandarte Island where 840 pairs have been recorded. Scattered pairs of Pigeon Guillemots nested throughout the region.

Clearly Mandarte Island was the most important nesting site in this region with about 3,100 pairs of nesting marine birds. Only Protection Island was larger and more important (diverse). About the same total numbers nested on Tatoosh Island. The Mandarte Island cormorant colonies were the largest in the study area and the adjacent Canadian waters. The island had 80% of all known nesting Double-crested Cormorants and 26% of all known nesting Pelagic Cormorants in the study area and the adjacent Canadian waters covered in this report.

C. Breeding Bird Species Accounts

Within the study area and the adjacent Canada there were about 39,000 breeding pairs of birds, representing 12 species (Table 5). Of this total about 34,000 pairs nested in the United States. Accounts of these species are presented with pertinent observations of their occurrence. All species discussed below are also found as nesting species on the outer coast of Washington (see Manuwal and Campbell 1979).

1. Fork-tailed Storm-Petrel

This species breeds in suitable habitat from northern California to Alaska (Palmer 1962). The species was found breeding only on Tatoosh Island at the western edge of the study area (Figure 8). It normally feeds offshore and was found only occasionally in the Strait of Juan de Fuca.

2. Leach's Storm-Petrel

This species is found nesting on suitable offshore islands from western Mexico to Alaska (Palmer 1962). The species was found breeding only on Tatoosh Island in the study area (Figure 9). Like the above species it feeds offshore, but it is even more pelagic in its habits.

3. Pelagic Cormorant

The Pelagic Cormorant nests on steep inaccessible cliffs, on offshore rocks and islands and headlands or man-made structures from Mexico to Alaska (Palmer 1962). The Pelagic Cormorant was found nesting in colonies throughout the study area (Figure 10). There were 17 nesting sites in this area, including four in adjacent Canadian waters. Altogether there were about 1,900 nesting pairs of which nearly 1,000 pairs nested in Canadian waters (primarily on Race Rocks and Mandarte Island). The two largest colonies in American waters were found on Tatoosh Island (200 pairs) and on Protection Island (295 pairs). Important colonies were also found on Colville Island, with about 115 pairs, and Smith Island, with nearly 100 pairs.

4. Double-crested Cormorant

The distribution of the Double-crested Cormorant is quite different from the above species, in that it nests not only along the coast of western North America, but is found nesting throughout much of continental North America (Palmer 1962). Unlike the Pelagic Cormorant, this cormorant nests on flatter areas, on ledges, and on the sides and tops of islands.

The Double-crested Cormorant was only about one-half as abundant as the Pelagic Cormorant, with under 1,100 pairs nesting in the study area and adjacent Canadian waters (Figure 11). Of this total, 840 pairs nested on Mandarte Island. The most important colony sites in American waters were on Bird Rocks (95 pairs), Williamson Rocks (73 pairs), and Colville Island (30 pairs).

Both cormorant species show annual variations in their utilization of colony sites. The Double-crested Cormorant often appears at colony sites late in the season and is somewhat less predictable in its time of breeding and location.

5. Black Oystercatcher

Here, as elsewhere along the Pacific Coast of North America, this species nests on the bare surface ledges. Obtaining accurate counts of this species was difficult as it is easily overlooked. There are probably at least 70 pairs in the study area and adjacent Canadian waters (Figure 12). Of this total, 50 pairs were recorded in American waters. This species was widespread and does not nest in large numbers at any one site.

6. Glaucous-winged Gull

The Glaucous-winged Gull nests from Washington north along the Pacific Coast of North America to Alaska (A.O.U. 1957). The Glaucous-winged Gull was the most widespread and conspicuous species in the study area (Figure 13). There were about 11,000 nesting pairs in the study area and an additional 3,000 pairs in adjacent Canadian waters. The largest Canadian colony was on Mandarte Island, where about 1,700 pairs nested. In American waters the largest colony was on Protection Island (4,300 pairs) with smaller colonies on Tatoosh Island (2,000 pairs), Colville Island (1,000 pairs) and additional smaller colonies.

Colonies were often found on mainland sites where small numbers or individual pairs took advantage of nesting opportunities on piers, roof-tops and derelict man-made structures.

7. Common Murre

This species nests from southern California north through Alaska (Tuck 1960). The Common Murre nested only on Tatoosh Island in the study area and there only numbered near 100 pairs (Figure 14).

8. Pigeon Guillemot

The Pigeon Guillemot nests along the West Coast of North America from southern California to Alaska (Udvardy 1963). This species was found nesting throughout the study area as scattered isolated pairs, small groups of nesting birds, and occasionally groups of several dozen or more pairs (Figure 15). In total, there were approximately 2,000 nesting pairs in the study area and adjacent Canadian waters. In the latter area there were about 120 nesting pairs, with the remainder of the total found in U.S. waters in the study area. Because of the difficulties of censusing this species most of the numbers of nesting birds of this species in the U.S. waters study area were derived from standard census methods as used for nonbreeding bird species (Figure 16). Notable concentrations were observed about Protection Island, Sucia Island and Puffin Island.

This species nested in a variety of natural and man-made sites such as cliffs, rocky crevices, burrows, under beach logs, and under piers. The number present at any given site was in part a function of the availability of nesting sites.

9. Marbled Murrelet

This species breeds along the coastline of North America from central California to Alaska (Udvardy 1963). It was apparently widespread in the study area, with scattered pairs occurring at numerous locations. However, unlike all the other species that nested in the study area and in the adjacent Canadian waters, a nest of this species has never been found in Washington. Thus, numbers that appear in Table 5 were derived entirely from standard census methods as for other nonbreeding birds and we assumed that the birds are feeding in areas relatively close to their nesting sites (Figure 17). However, this may not be entirely true as this species in some cases may be flying several miles inland, i.e., up rivers, to nesting sites. We projected that the total breeding population in the study area and the adjacent Canadian waters totals about 1,000 pairs, with almost all of these in U.S. waters.

10. Cassin's Auklet

This species breeds on appropriate island habitat from Baja California, Mexico to Alaska along the Pacific Coast shoreline of North America (Udvardy 1963). The Cassin's Auklet was found as a breeding bird in the study area only on Tatoosh Island (Figure 18), where a small colony of about 300 pairs existed.

11. Rhinoceros Auklet

Rhinoceros Auklet nests on suitable islands from Central California to Alaska (Udvardy 1963). There were only three known nesting sites of this species in the study area (Figure 19), with none known for the adjacent Canadian waters. The largest colony was located on Protection Island with a population of about 17,000 nesting pairs of birds. Other colonies included 600 pairs on Smith Island, and about 300 pairs on Tatoosh Island. The

Protection Island population was the single largest colony of this species in the contiguous United States and represented over half of all the known breeding birds in the study area.

12. Tufted Puffin

This species nests on appropriate coastal islands from central California north through Alaska (Udvardy 1963).

There were only 8 known or very likely nesting sites of this species in the study area (Figure 20). Major sites were on Tatoosh Island, Seal and Sail Rocks and Protection Island. The total population was small and is apparently lower than in historic times.

D. Composition of Marine Bird Populations

Breeding populations may represent only a small portion (40%) of the total numbers of marine birds using the study area (See Appendix C). Nonbreeding age classes of species which nest here were not separately quantified. Pre-breeding (immature) cormorants and Glaucous-winged Gulls in particular may account for large numbers of birds. Most Glaucous-winged Gulls do not breed until 5-6 years old. There were large numbers of immatures present in the study area year-round. Table 6 gives the general density (birds/km^2) within several habitat types in the study area. Appendices D through I contain numerous examples of seasonal changes in bird families in terms of density and projected totals. The species and age composition of marine birds in the study area changes seasonally.

1. Seasonality

a. Summer. Population size (density) (Table 6) was the lowest during the summer. Populations then were composed of breeding birds and nonbreeders of nesting species plus nonbreeding populations of other species such as scaup, scoters, other diving ducks, and several species of gulls. This season was about one month long (June) and occurred at the end of spring migration and prior to the first stages of fall migration which began in late June-early July. Populations were concentrated near colony sites and foraging areas, roosts used by nonbreeders, and localized areas used by nonbreeding ducks, gulls, and other species which nest outside the study area. Since diving birds, for example, may be flightless during moult, they are extremely vulnerable to disturbance and stress at this season. Examples observed included numbers of diving ducks at Padilla Bay and Boundary Bay during the summer, a flock of up to several hundred Western Grebes summering on northern Bellingham Bay, and several hundred immature Brandt's Cormorants roosting on Whale and Mummy Rocks and foraging in tidal convergences throughout the San Juan Islands area.

b. Spring and fall. Migration is a transition between the two seasons in which birds are basically resident. Spring migration (April and May) added large numbers of birds to resident species in the study area. Residence time of a given individual migrant in the study area may be relatively

Table 6. Average seasonal bird densities (birds/km^2) within several selected habitat types in the study area, 1978-1979 (Appendix I).

Habitat	Season Spring	Summer	Fall	Winter
Open Water Georgia Strait (0703)	9.2	2.7	2.7	3.5
Open Water Strait of Juan de Fuca (0201)	3.5	1.2	71.5	19.6
Broad Passage Rosario Strait (offshore; 0901)	6.2	3.2	35.6	84.8
Broad Passage Admiralty Inlet* (offshore; 0401)	72.0	119.5	88.3	50.8
Narrow Passage Active Pass (1301)	537.0	14.5	99.4	385.5
Rock shoreline, no shelf Orcas Island (nearshore; 1002)	22.7	15.9	141.5	69.4
Cobble Beach Cherry Point (0602)	1,370.1	38.8	38.5	126.9
Broad shelf, eelgrass Jamestown	720.5	525.9	1,305.8	1,164.5
Shallow bay, eelgrass Padilla Bay (0504)	575.0	61.3	312.5	1,050.0

*1979 data only (Appendix H).

brief, as breeding imperatives generally keep birds moving in spring. Migrating populations in spring were chiefly composed of breeding adults. Birds foraged in available habitats, including tidal flats exposed by low spring tides, newly-plowed fields, tidal convergences and locations where marine animals spawn. Two events contributed to large local concentrations at this season. Herring spawning activities, primarily at Discovery Bay and Eastern Georgia Strait, attracted large numbers of birds (see V-E). The other event was the spring migration of Black Brant which, in contrast to a rapid southward movement which brings only a few thousand birds to spend the winter at Padilla Bay and a few other subregions, began in March and was a leisurely movement involving many thousands of birds (see Figure 22 for examples of seasonal changes). Up to 50,000 birds foraged in the eelgrass beds of Padilla Bay, and thousands more were found in other shallow bays throughout the area. These events added substantially to biomass and vulnerability ratings of the study area in spring.

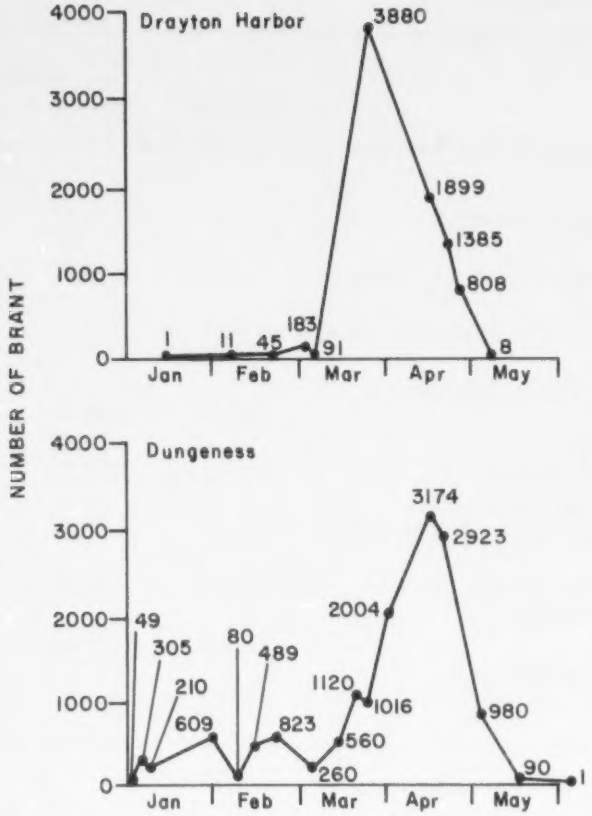

Figure 22. Numbers of Black Brant observed on censuses of Dungeness Bay/Harbor and Drayton Harbor during 1979, January through May.

Fall migration began in late June-early July with the arrival of Western Sandpipers and Bonaparte's Gulls from the north and extended through October. It may continue as late as November when swans pass through. Fall migration was more leisurely than the spring movement. A large percentage of the population at this season was made up of birds hatched within the preceding few weeks or months, and total populations were generally larger than in spring. The fall population thus represents a large number of young birds destined not to survive their first winter (about 60% in the case of Glaucous-winged Gulls, [Ward 1973] for example), as well as the next year's breeding population.

Generally, species richness is greater in the fall (Table 7). This is the season of greatest numbers of shorebirds in the study area. Large flocks of gulls gather along the shoreline of the Strait of Juan de Fuca to forage on late-summer-fall fish schools. One species, Heermann's Gull, migrates north in late spring and summer and resides in the study area until moving south in late October-November to nest in the Sea of Cortez. Gull populations in the study area are probably largest during the fall migration period. This season also includes the departure of most Rhinoceros Auklets which nest in the study area and winter along the Pacific Coast of the United States. About the same time, large numbers of species like Common Murres enter the study area for the winter.

Table 7. Seasonal species richness (number of species) within several habitat types of the study area.

Habitat	Season Spring	 Summer	 Fall	 Winter
Open Water (Georgia Strait)	25	6	29	29
Broad passage (Rosario Strait)	24	7	25	28
Broad Passage (Admiralty Inlet)	21	6	24	30
Tidal passages (Active Pass, Thatcher Pass, Speiden Channel)	30	14	31	40
Rock shoreline, no shelf (San Juan Islands)	21	8	29	31
Cobble beach (Cherry Point, (Whidbey Island)	39	23	49	50
Broad shelf, eelgrass (Padilla, Fidalgo, Lummi, Birch Bays, Drayton Harbor)	60	39	68	66

c. Winter. With few exceptions, populations of all subregions peaked during the winter. Large numbers of diving birds of many species entered inside waters in late fall and remained, in some cases, until May (see Figure 23 for examples of seasonal changes). Loons, grebes, cormorants, and alcids from many other regions wintered here. Dabbling and diving ducks, geese and swans made up a large component of winter bird populations, and large numbers of northern-breeding gulls were added to resident populations of Glaucous-winged Gulls. Shorebirds were represented primarily by large flocks of Dunlins, with other species making up a very small fraction of the total.

Winter populations are composed of large numbers of vulnerable species. They are influenced by stress imposed by winter weather conditions, restricted foraging opportunities due to tidal cycles and limited hours of daylight, and potentially by greater likelihood of man-caused accidents.

E. Foraging Habitats

The areas where marine birds obtain their food are vital for their survival. The availability of productive foraging areas probably limits breeding activity within the study area, as unused nesting habitat appears available. Table 6 shows that density varied between habitat types in the study area. The most heavily-used types of foraging areas included those discussed below. See Appendices D through I for subregional family densities and projected totals.

1. Bays

Excluding cobble shoreline locations where large concentrations of birds were attracted to seasonal herring spawning activity, the highest consistent seasonal densities of birds were observed in shallow bays (we include "estuaries" in this category). Average density of all species observed in Drayton Harbor in winter 1978-1979, for example, was 877 birds/km^2 (Appendix I). The average densities of birds observed during that season over open waters were 77/km^2 in Georgia Strait-Eastern (Subregion 0608), 4/km^2 Georgia Strait-Western (0703), 22/km^2 in the Strait of Juan de Fuca-Inner (0301), and 20/km^2 in the Strait of Juan de Fuca Strait-Outer (0201). Similar contrasts are evident when densities of other shallow areas are compared with open waters.

Many of the shallow bays in the study area have eelgrass beds which attract many species. Other highly productive shallows support important benthic and neritic prey communities which in turn support a wide variety of bird species.

Populations in bays often tended to be relatively sedentary, in contrast to highly mobile populations of fish-eating diving birds which utilized deeper habitats offshore and in tidal convergences. Large numbers of dabbling ducks and shallow water divers like grebes appeared to be local residents all winter in Padilla Bay, for example, and except for hunting disturbance, moved relatively short distances. Dabbling ducks, however, move into adjacent fields to forage. Open water species such as Arctic Loons, on the other hand, appear to

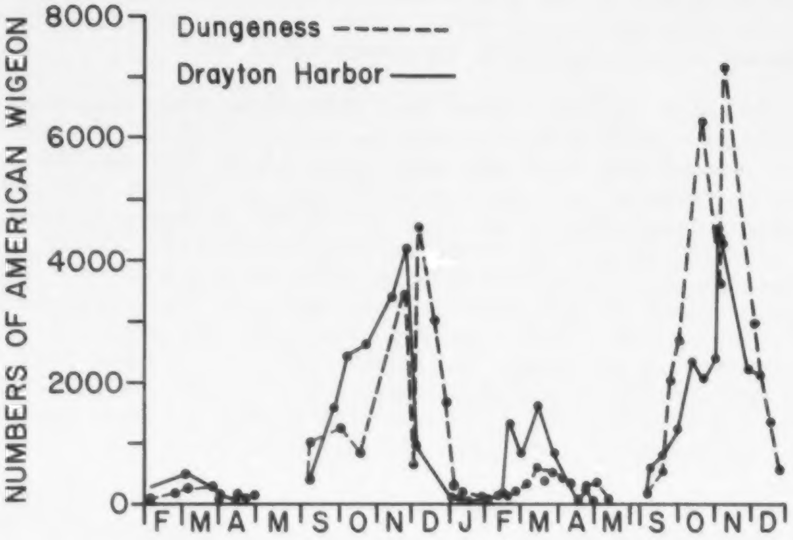

Figure 23. Numbers of American Wigeon observed on censuses of Dungeness Bay/Harbor and Drayton Harbor during 1978 and 1979.

move long distances and this mobility is probably related to movements of fish schools.

2. Shallow Shelves and Open Shorelines

Shallow areas off open shorelines, as at Jamestown or "outer" Boundary Bay east of Point Roberts, supported populations comparable in density to those in more protected bays or enclosed harbors. There were relatively few of these subregions in the study area, but they were quite important to bird populations. Average winter populations at Jamestown were projected at about 25,000 during this peak season (Appendix Table I-3).

Narrow shelf habitats along open shorelines generally supported lower populations of marine birds, partly due to the limited area available. Vegetation, substrate types and associated biological communities varied primarily in relation to degree of exposure to wind and wave energy. Some severe wave action shorelines, like Ediz Hook, appeared to have very low numbers of birds associated with the substrate itself, though flocks of fish-eating species were observed foraging there on a number of occasions. Winter-season populations in the Ediz Hook subregion in 1979 averaged about 38/km^2 (Appendix Table I-3). When data for birds directly associated with fish and/or roosting on the beach (gulls and terns) were subtracted (data in Appendix Table F-12), the number engaged in foraging solely on the shoreline or on nearshore bottom organisms was about 24/km^2. These were among the lowest of any nearshore densities in the study area.

Open shorelines with adjacent kelp communities, as found along the western shoreline of Whidbey Island, have locally high populations of several species (such as Red-necked, Horned and Western Grebes, Pelagic Cormorant, Harlequin Duck and other diving ducks, Heermann's Gull [in summer and fall] and other species) which appear to associate frequently with this habitat type. Populations in 1978-1979 along the Whidbey Island subregion shoreline were about 126/km^2 in winter, and 200/km^2 in fall (Appendix Table I-3).

In contrast, "no-shelf" open shorelines which drop almost vertically to deep water have relatively low bird populations associated with them. This is not a widespread habitat type but is found in the San Juan Islands, such as along the northeastern shoreline of Orcas Island (Table 6). If one flock of Western Grebes and one of Bonaparte's Gulls feeding within 75 m of shore in tidal convergences were excluded from these figures, densities of birds observed foraging immediately along this shoreline itself in the 1979 aerial censuses ranged from about 10-70/km^2.

3. Fronts or Convergences

Relatively low densities of birds used the deeper, open-water habitats exemplified by the offshore components of Juan de Fuca, Georgia, Rosario, and Haro Straits. However, within these large areas, foraging birds concentrate in many localized areas of tidal convergence which in effect are transitory, consistently recurring subhabitats within the larger water bodies.

Active Pass, in the Canadian Gulf Islands, is perhaps the most outstanding example of this phenomenon within the inland waters area. Because of the constriction of strong currents flowing between Mayne and Galiano Islands, the effect is more extreme here than in open water current boundary areas. As an example of variation within tidal cycles, however, data from censuses done within about 2.2 hours on round-trip ferry runs showed regular variations in densities of birds of about 50-230%, with an extreme variation of 3,700%. Other areas illustrating this phenomenon are Deception Pass, southern San Juan Channel, and Wasp, Obstruction and Thatcher Passes. Tidal currents attract birds around many rocks, islands, and "points" in the study area. Examples include the Peapods in Rosario Strait, the southern shore of Lopez Island, and the western points of Patos and Stuart Islands in particular. Convergences form and attract birds in open waters and broad channels in many locations including Rosario Strait, Admiralty Inlet, Point Roberts, Point Wilson, Ediz Hook, Speiden Channel, San Juan Channel, Upright Channel, Guemes Channel, Bellingham Channel, and Hale Passage.

4. Offshore Kelp Beds

While bird densities in open waters were generally low relative to nearshore areas or shallow bays (Table 6), birds often concentrated well offshore at relatively shallow rises and kelp beds. While quantitative data are limited, cormorants and other species of nearshore affinities were observed foraging over Alden Bank, southwest of Cherry Point, during regular census flights over eastern Georgia Strait offshore waters.

During an aerial survey of Rhinoceros Auklet distribution in July 1979 (Figure 6), we observed Rhinoceros Auklets and other birds concentrated in kelp beds over Partridge and Hein Banks in the Strait of Juan de Fuca-Inner (Figure 26). This habitat, along with areas of tidal convergence, likely supports an important proportion of birds foraging away from shallow bays and shorelines of the study area.

5. Herring Spawning Beaches

A phenomenon observed in 1978 involved large concentrations of birds, primarily scoters, gathering to feed on herring spawn during late winter-early spring. Herring spawn in several areas in Washington's inland waters (Trumble et al. 1977), though within this study area its effects on bird populations were observed only in Discovery Bay and Georgia Strait-Eastern. Trumble et al. (1977) indicate that the northern Whatcom County shoreline (Georgia Strait-Eastern) is the most productive herring spawning habitat in Washington, and the only area which supports a sac roe fishery. We observed very large flocks of birds, particularly near Cherry Point, Whatcom County, in April-May 1978. For example, about 25,000 scoters were observed feeding at Point Whitehorn (Cherry Point subregion 0602) on one occasion. We flew five flights about one week apart around the perimeter of Georgia Strait-Eastern in April-May 1979 to further assess the extent of this concentration. Separate census data from these flights could not be presented in this report and detailed analysis will be given elsewhere. However, high seasonal projections in

Appendices D-I of waterfowl (Table F-38) and all species (Table I-6) in spring result primarily from scoters observed from these supplemental flights.

With the exception of breeding birds on Protection Island and foraging Black Brant and ducks or roosting gulls and shorebirds, the spring season density of 1,370/km^2 at Cherry Point (Table I-6) was the highest seasonal density calculated during the study. We emphasize, however, that these projections characterize average seasonal populations not peak numbers. This density can be compared to the spring density of 27 birds/km^2 at Whidbey Island (0313), a somewhat similar cobble beach habitat where herring spawning does not occur. It can also be seen that densities at Cherry Point in summer, fall, and winter--when the attraction of herring spawn is lacking--were much lower than spring density and were particularly low when compared to adjacent protected embayments like Lummi Bay (0601) and Birch Bay (0603).

While locations and amounts of herring spawn are variable from year to year (Trumble et al. 1977), the largest 1978-1979 bird concentrations observed in herring spawning areas were along the Georgia Strait-Eastern shoreline from Sandy Point north to Point Whitehorn and from Birch Point to Semiahmoo Spit (Birch Point-Semiahmoo subregion 0604). Other than Surf Scoters, which were by far the predominant species, and White-winged and Black Scoters, several other species were observed directly associated with herring spawn. These included Harlequin Ducks, Oldsquaws, and Glaucous-winged, Mew and Bonaparte's Gulls. Some of the study area's largest concentrations of these species were observed at herring spawn locations. In addition, large numbers of several other species occurred in Georgia Strait-Eastern at this season, and were almost certainly involved with the herring run itself. These were fish-eating species such as the Arctic Loon, Common Murre, and Marbled Murrelet (see Appendix K). The importance of herring spawn to marine bird populations and implications of perturbances on herring spawn deserve further, intensive study.

F. Movements

Marine birds are extremely mobile. The main types of movements observed included seasonal migrations into and out of the study area, and regular movements relating to foraging and roosting/breeding areas.

1. Migration

The study area lies in the Pacific Flyway, which means that many birds pass through the area on their way north or south. The study area does represent an important southern terminus of migration for many northern breeding species.

Migration was generally not obvious during censuses within the study area. Unlike open coastal areas where vast numbers of loons or waterfowl may be observed passing, the effects of migration in the geographically complex study area were noted primarily through the presence or absence of species or large variations in numbers observed on consecutive censuses. Obvious migration was exemplified by flocks of Oldsquaws flying south past Point Roberts, and flocks of Snow Geese (seldom observed within the study area itself) dropping from high altitude to almost water level over Padilla Bay and continuing south over the Swinomish Flats to wintering grounds in the Skagit Delta. Undoubtedly, dawn-to-dark sea watches at strategic points during migration seasons would show migration patterns. That type of intense sampling effort was beyond the scope of the present study.

2. Daily Movements

Daily movements of birds from roosts and colonies to foraging areas were quite often observed both during sea watches and incidentally at other times. These involved both direct daily movements which were quite regular, and subsequent opportunistic movements responding to local feeding conditions. The initial movements appeared to take place from first light for about two hours, with a similar pattern, perhaps more prolonged, for about two to three hours before dark. Rhinoceros Auklets, for example, left Protection Island before first light and did not return until well after dark, spending some time in "staging" areas near the colony just before dark.

During nesting seasons, most of the movements were between colonies and foraging areas (Figure 24). Some of these were on a very large scale, as in the case of Rhinoceros Auklets (Figure 25), which, because 97% nest on one colony, were obvious as to origin and destinations. The interrelationship of nesting and foraging areas is extremely important, and these habitats cannot be considered separately. The importance of Admiralty Inlet to the nesting birds of Protection Island is reflected by our estimate of one-third of the Protection Island Rhinoceros Auklets being present in Admiralty Inlet on one occasion (Figure 26). After nestlings leave the colonies the necessity for daily returns to colonies ceases, and more distant foraging areas may be used.

The location and use of roost sites (see V-G) are important features of the study area that are involved in the movements of birds. During nonbreeding seasons, almost all the nesting colony sites (except those of burrow-nesters) are used as night roosts. Since winter populations are larger, winter usage of roost sites is likely heavier than in summer. In addition, a number of sites used as roosts alone contribute substantial numbers of birds into a web of movement routes throughout the study area.

Observed movements of cormorants between roosts and foraging areas in northern subregions are shown in Figure 27. These are not all the routes used, though certainly the major ones. Note that some movements are extensive, with the extreme case being that of Double-crested Cormorants which roost along the south shore of Lopez Island and on rocks within Rosario Strait and perform daily flights as far as Skagit Bay and up Rosario Strait and Guemes Channel (or over Anacortes) into Fidalgo, Padilla and Samish Bays. Some Brandt's Cormorants, on the other hand, roost on Whale and Mummy Rocks and forage within a few hundred meters away in San Juan Channel. Whether the same individual birds travel to the same foraging areas each day, or indeed return to the same roost rock each night is unknown, but observations showed the general movements were quite consistent.

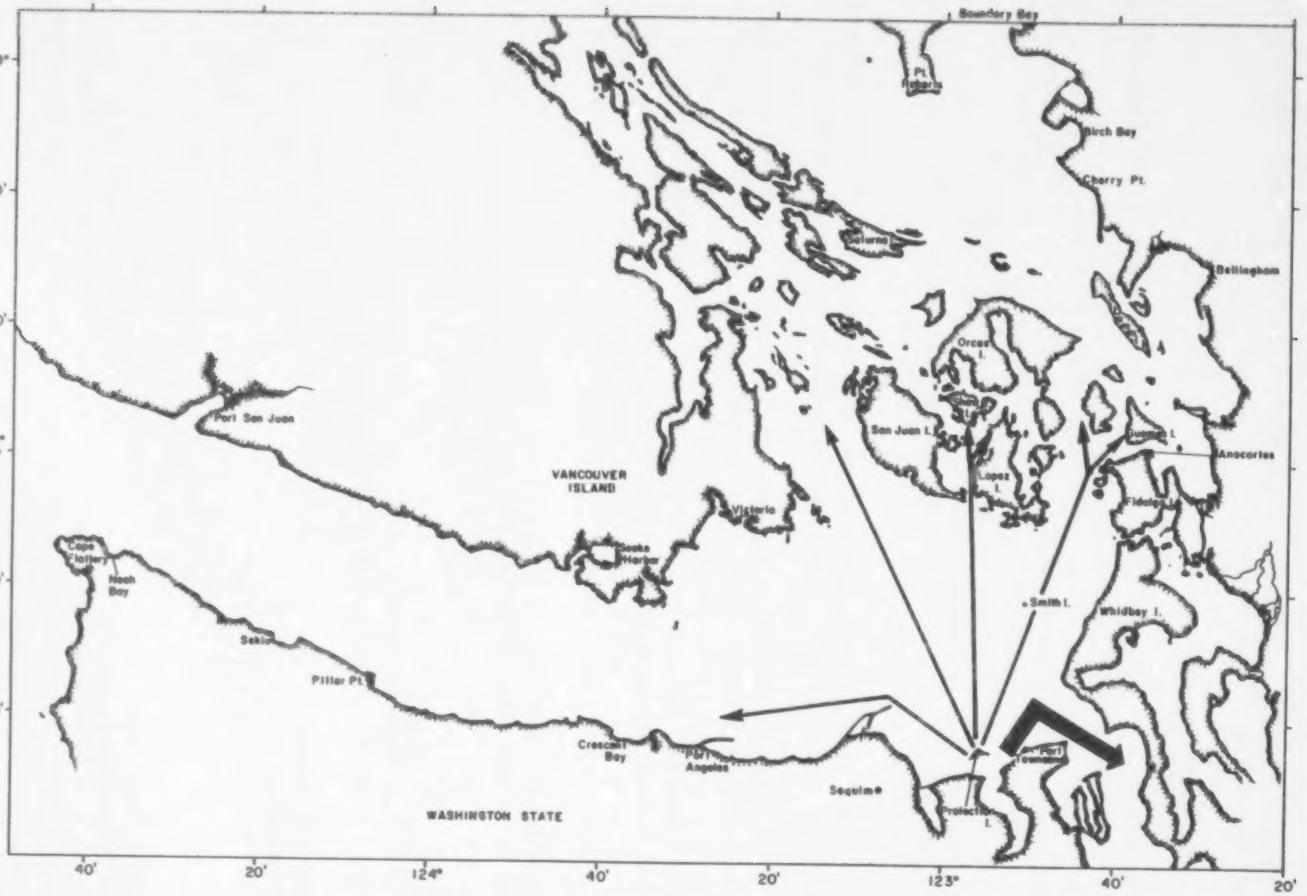
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna
Orcas I.
San Juan I.
Lopez I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port Townsend
Protection I.
Sequim
Port Angeles
Crescent Bay
Pillar Pt.
Sekiu
Neah Bay
Cape Flattery
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
WASHINGTON STATE

Figure 24. Map showing routes of daily major movements of Rhinoceros Auklets foraging away from Protection Island, during chick rearing stage.

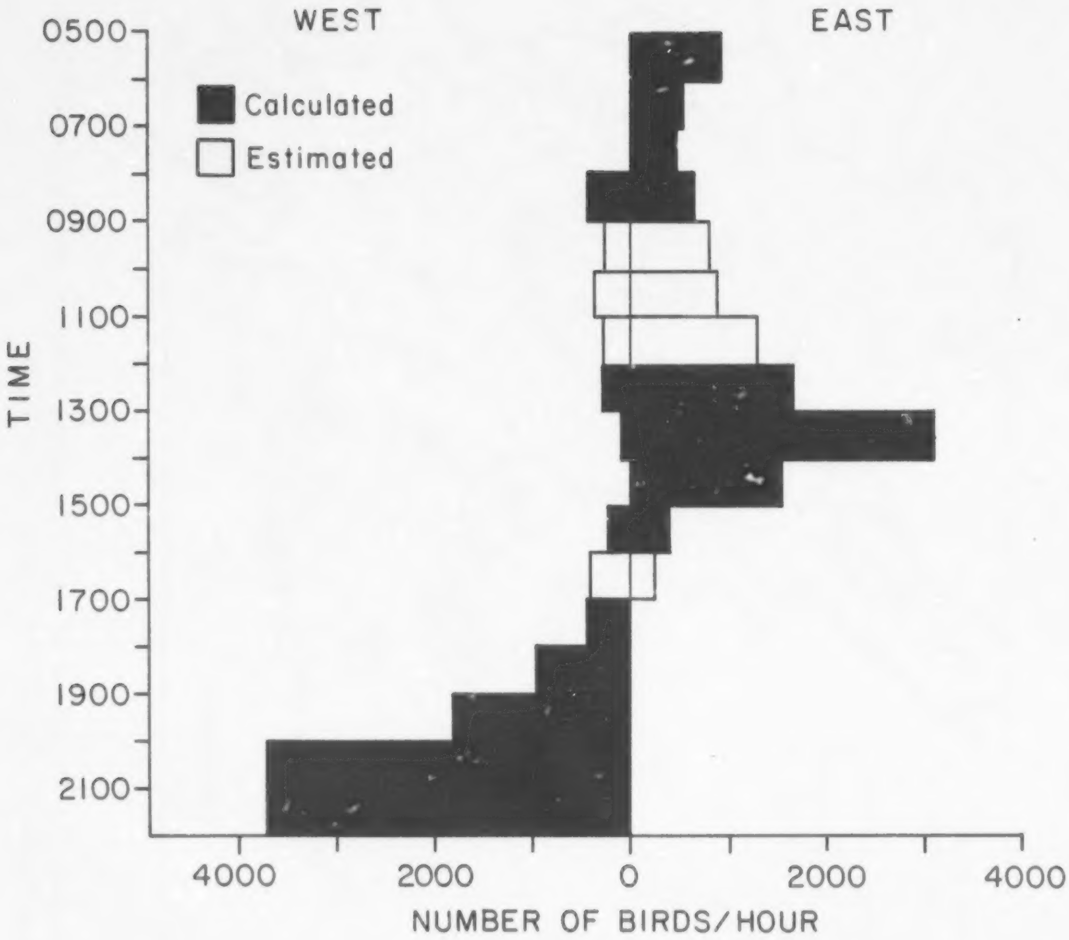

Figure 25. Figure showing the magnitude, direction, and time of movements of Rhinoceros Auklets passing Point Wilson going to and from foraging areas and Protection Island, during chick rearing, July 1979.

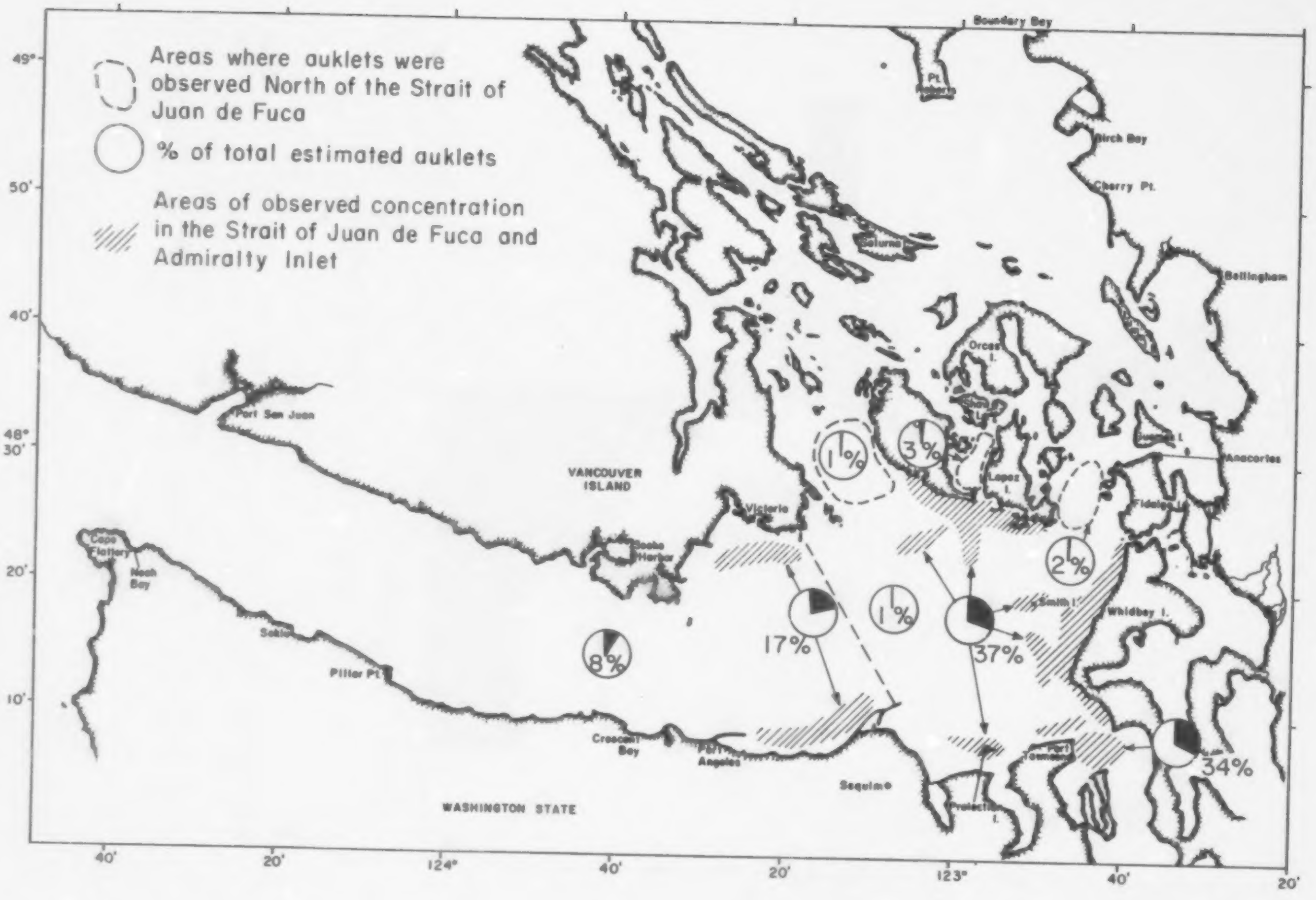
Areas where auklets were observed North of the Strait of Juan de Fuca
% of total estimated auklets
Areas of observed concentration in the Strait of Juan de Fuca and Admiralty Inlet
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Galiano
Orcas I.
Shaw I.
Lopez I.
Anacortes
Fidalgo I.
Whidbey I.
Smith I.
Port Townsend
Protection I.
Sequim
Port Angeles
Crescent Bay
Pillar Pt.
Sekiu
Neah Bay
Cape Flattery
Port San Juan
VANCOUVER ISLAND
Sooke Harbor
Victoria
WASHINGTON STATE
1%
3%
2%
1%
17%
37%
34%
8%

Figure 26. Map showing the locations of major foraging areas of Rhinoceros Auklets feeding chicks on Protection Island, July 1979.

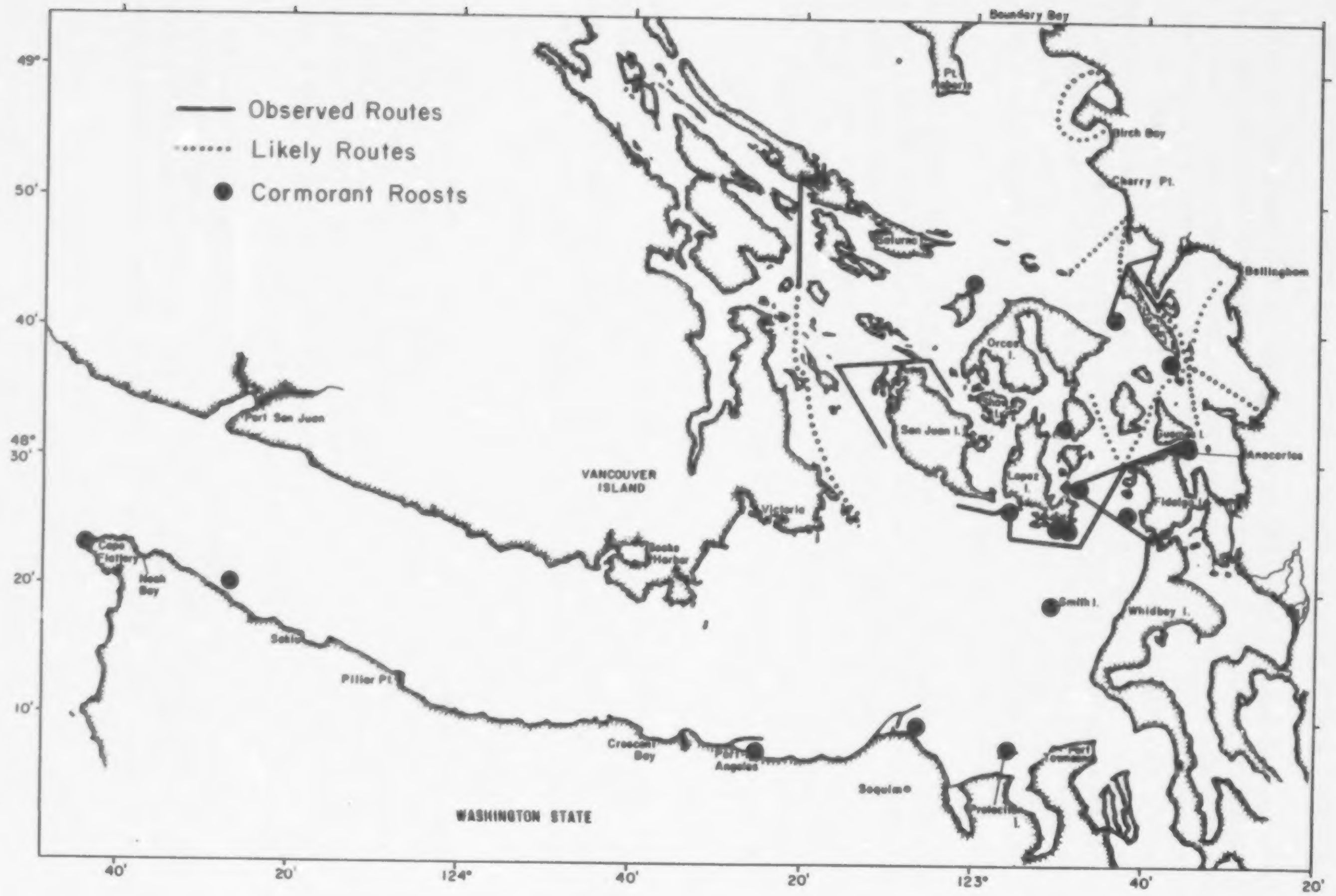
Observed Routes
Likely Routes
Cormorant Roosts
Boundary Bay
Pt. Roberts
Birch Bay
Cherry Pt.
Bellingham
Saturna
Orcas I.
San Juan I.
Lopez I.
Guemes I.
Anacortes
Fidalgo I.
Smith I.
Whidbey I.
Port San Juan
VANCOUVER ISLAND
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Protection I.
Port Townsend
WASHINGTON STATE
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 27. Map showing the locations of important cormorant roost sites and routes of significant daily movements.

Many diving birds like loons, grebes, and alcids spend the night on the water. Some grebes, for example, were not observed moving in regular patterns and apparently roosted essentially near foraging areas. Other species, particularly some alcids like the Common Murre, were observed performing regular morning and evening flights. Common Murres moved up Rosario Strait each morning where many were observed landing to feed in tidal convergences, especially in Southern Rosario Strait. These birds may spend the night somewhere offshore in the Strait of Juan de Fuca, perhaps feeding on nocturnally available plankton, and moving to Rosario Strait and other areas during the day.

Observed movements have implications as to the numbers of birds censused during daylight hours at a given location. Censuses made during the day understate maximum numbers using roosts, colony-sites, and offshore nocturnal concentration sites. Likewise, many foraging areas may be relatively unpopulated during the night, though this latter possibility is much less certain than the first. Bird movements may affect relative numbers projected to different subregions. For example, Double-crested Cormorants roosting on Bird Rocks in Rosario Strait flew to forage in Padilla Bay. Some Double-crested Cormorants from Bird Rocks appeared to leave the study area through Deception Pass. The daily movement of Rhinoceros Auklets from Admiralty Inlet into Puget Sound also takes them out of the study area.

Largest movements observed during the study were those of birds (primarily Rhinoceros Auklets) moving between Protection Island and Admiralty Inlet, cormorants and Common Murres in Rosario Strait, and cormorants dispersing from Mandarte Island, British Columbia, to Speiden Channel and San Juan Channel and unknown foraging areas. Large-scale daily movements of Arctic Loons and Common Murres are likely, but other than those in Rosario Strait such flights were not documented in the study area.

G. Roosts

When not feeding, marine birds spend much of their time roosting on land or water. This aspect of the life history of birds is often overlooked and understated. Nevertheless, where birds are harassed (so as to reduce their roosting time) increased mortality and dispersal have been observed.

1. Types of Roosts

There are several types of roosts utilized by marine birds. In the study area, we recognized the following seven types of roosts: rocks/islands, spits, beaches, mudflats, log booms, man-made objects, and the water surface itself. These roosts may be used during the night or day, depending on the activity patterns of the birds and their response to tidal fluctuations. Our knowledge of roost utilization is primarily from daylight hours since very few night observations were made during this investigation.

a. Rocks and Islands. Rocks and islands were used as roosts by Glaucous-winged Gulls, Double-crested Cormorants, Pelagic Cormorants, Brandt's Cormorants, and Black Oystercatchers. All of the islands which had breeding colonies (Figure 21) also supported roosting populations during the nonbreeding seasons. In addition, Willow Island, Whale and Mummy Rocks, and the southeast tip of Guemes Island were used as roosting sites by cormorants. The rocks on the south shore of Lopez Island were also important as roosts for cormorants. Many of the cormorants roosting in this area commuted daily around and over Shannon Point/Anacortes to spend the day feeding in Samish, Fidalgo and Padilla Bays. Seasonal migrants such as the Heermann's Gull and Mew Gull used islands for roosting. Winter residents, i.e., Black Turnstones, Surfbirds, and Harlequin Ducks, used exposed rocks as roost sites. In many cases the birds roosted at high tide, then left the rocks during low tide to forage. Even small rocks were extensively utilized as roost sites.

b. Spits. Spits were very important roost sites. In many cases birds used a roost site because there was a decreased chance of predation there. The ends of spits, for instance, provide areas where birds are exposed to potential ground predators from only one direction. Dungeness Spit was used by Glaucous-winged, Mew, California and Heermann's Gulls, and Black-bellied Plovers, Sanderlings, and Dunlin as a roosting site during high tides of the daylight hours. In addition, Spencer Spit on Lopez Island, Sidney Spit and Kirby Spit in Samish Bay were used as roost sites by gulls and shorebirds as was the spit at the entrance to Sequim Bay. There were very few large spits in our study area, but small points of land also served as roost sites. A "disturbed" spit such as Ediz Hook with its heavily used road and Coast Guard station was utilized less as a roosting area by birds.

c. Beaches. Extensive gravel and sand beaches were used as roosting sites but the birds were generally not as concentrated as in the previous two types. Bald Eagles occasionally roosted on intertidal zones and in trees adjacent to the beach. Shorebirds and gulls roosted on the upper intertidal zones, particularly on undisturbed areas. Beach areas with large concentrations of roosting birds included the south shore of San Juan and Lopez Islands, and smaller numbers at the mouths of rivers such as the Dungeness, Twin, and Nooksack Rivers. Dabbling Ducks such as Mallards, Green-winged Teal, and Pintail often used the beaches for both daytime and nighttime roosts, particularly in estuaries such as Drayton Harbor. Gulls used beaches as roosts during low tide.

d. Mudflats. Mudflats were occasionally used as roost sites by gulls, but were used more heavily as foraging areas. Waterfowl often roosted on exposed mudflats.

e. Log Booms. While not a traditional type of roost, log booms are now important, perhaps due to disturbance on many traditional roost sites. In Port Angeles along Ediz Hook there is virtually no undisturbed shoreline remaining. In such areas the log booms are used by thousands of birds as roost sites. These included Brandt's and Pelagic Cormorants, Mew, California, Glaucous-winged, and Bonaparte's Gulls, Black-bellied Plovers, Black Turnstones, Dunlins, Common and Barrow's Goldeneyes, scaup, dabbling ducks, and Great Blue Herons. Log booms used as roosts were also found in Neah Bay, Sequim Bay, Bellingham Bay, and near March Point in Padilla Bay. Individual floating logs, both moored and free-floating, were also used as roosts.

f. Man-made Objects. Man-made objects such as buoys, jetties, piers, pilings, dolphins, and even buildings were utilized by cormorants and gulls as roost sites. These structures are scattered throughout the study area. Examples include dolphins in Port Angeles and Drayton Harbors, a deteriorating pier at Jamestown, the jetty at Neah Bay and Port Angeles, and buoys in the shipping lanes.

g. Water Surface. The water surface itself was used for roosting by many species. Diving ducks, including Bufflehead, Common Goldeneye, scaup, scoters and Oldsquaw all used the water surface for roosting. Very large numbers of loons, grebes, and alcids spend their nonbreeding lives in the study area and these diving birds spend virtually all their day cycles foraging underwater and resting on the surface. Many species fed in nearshore areas and then moved offshore to roost at night; other species both fed and roosted in the same area, such as in the center of bays.

2. Importance of Roost Sites

In general, roosts had distinct patterns of attendance. Rocks and islands were used primarily at night and daytime and during high tides. Spits were used at night and at high tide. Beaches were used at any time. Mudflats were used at low tide. Log booms and man-made objects were used at all times, and the surface of the water was used primarily at night by seaducks and during the morning hours by loons, grebes, and alcids.

Roosts may also have distinct seasonal patterns of use. Log booms, spits, and beaches had the highest gull attendance during the migration and wintering periods. When birds were nesting during the summer months, only the immature and nonbreeding birds remained to use the roost areas. These sites were important to all species of birds in the study area. They provided areas for birds to rest, preen, and dry their plumage.

a. Night Roosting of Scoters. This study provided opportunities for some observations of nighttime behavior of scoters. From a total of 4 hours of dusk observations on different days, and 2 hours of night observations the following results were obtained. White-winged Scoters stopped feeding at sunset and began to move offshore. If the birds were in a bay they swam slowly to the center of the bay. If they were along a coast line they swam offshore. In the half hour before they swam offshore, preening/sleeping activity increased significantly. Surf Scoters and Black Scoters were also observed to swim away from the shoreline areas that they frequented during daylight. From two hours of night observation done from a boat in Sequim Bay, it was concluded that these ducks were not present along the shore.

From three hours of dawn and pre-dawn observations it was concluded that the three species of scoters remain in offshore roosting ares until about 10 minutes before sunrise. The birds were then observed to swim to shoreline feeding areas and feed intensively for the first one hour of daylight. Although actual night roosting areas were not seen, scoters most likely roost in large concentrations in the center of bays, and offshore from their daytime feeding areas. They would potentially be exposed to oil at all times, like other divers, since they are essentially confined to the water from fall until leaving on spring migration.

b. Effect of Disturbance on Roosting Birds. Birds often returned to a site after being temporarily disturbed. In areas where there was continual disturbance, such as in a busy commercial harbor or near heavily used marinas, birds were less apt to fly when approached. However, in areas such as Jamestown with less traffic, a raft of 15,000 wigeons could be flushed by merely the passing of a boat. Also, certain species were more easily disturbed than others. Hunted species of diving and dabbling ducks flushed very easily from their roost sites as did shorebirds. Brant and Snow Geese also were very susceptible to disturbance. Brant did not return to a feeding or roosting area once they had been disturbed. Cormorants were easily frightened and flew off roosting rocks when approached. Gulls, Harlequin Ducks, and grebes appeared to have shorter 'flight distances' and were less easily disturbed.

c. Loss of Roost Sites. If the roosts are destroyed or otherwise made unavailable, it is uncertain what effect this would have. In areas such as Ediz Hook where spit roosts were unavailable, the birds used other objects such as piers and log booms. In areas such as Bird Rocks which was bombed extensively in the past, birds have recolonized and now use the site for both nesting and roosting. This evidence suggests some adaptability in terms of use of roost sites. However, the vital importance of roost areas in terms of safety from predation and nesting must not be understated.

In many management plans, only breeding sites are considered noteworthy. We stress the importance of roosts. They provide areas where essential activities such as preening and resting can occur. Roosts also serve as "concentration" points for birds and consequently as locations of special vulnerability.

H. Marine Bird Mortality

An index of bird mortality was obtained by recording the number of dead birds observed on beach walks, ferry transects, and aerial transects. Obviously, not all dead birds were seen, and some were consumed by scavengers or decomposed offshore. Furthermore, not all dead birds floated or washed ashore and those that did were often eaten by the numerous scavengers, such as Bald Eagles, gulls, crows, several carnivorous wild mammals, and domestic dogs. Losses from scavengers result in a bias toward underestimating the number of dead birds. Storms and high tides either deposited dead birds on beaches or washed them off beaches, thus contributing additional biases to dead bird censusing. Nevertheless, these censuses provide trend values which can be used for comparison in the event of an oil spill. See Figure 5 for locations of beaches censused for dead birds.

1. Mortality Rates Derived from Beach Walks

The number of dead birds recorded in the study area in 1978 and 1979 is typically low (Tables 8 and 9; Figure 28). Any sizable number of dead birds found in a relatively small area at the same time is an indication of abnormally

Table 8. Frequency of dead birds found on beach walks at selected beaches in 1978 and 1979.

Site	Beach Length (km)	Number of censuses 1978	Number of censuses 1979	Number of birds 1978	Number of birds 1979	Number of months 1978	Number of months 1979	Censuses per month 1978	Censuses per month 1979	Rate[1] (Birds/km/census) 1978	Rate[1] (Birds/km/census) 1979
Bellingham Bay No. 1 (1)[2]	1.0	13		1		8		1.6		0.08	
Bellingham Bay No. 2 (2)	2.3	14		2		10		1.4		0.06	
Birch Bay No. 1 (3)	1.9	3		0		2		1.5		0	
Cherry Point No. 1 (4)	1.9	3		0		1		3.0		0	
Cherry Point No. 2 (5)	2.0	4		2		3		1.3		0.25	
Clallam Bay No. 2 (6)	1.7	3		0		1		3.0		0	
Clallam Bay No. 3 (7)	1.3	4		1		2		2.0		0.19	
Crescent Bay No. 1 (8)	2.0	1		0		1		1.0		0	
Deception Pass No. 1 (9)	1.1	11		1		8		1.4		0.08	
Deep Creek No. 1 (10)	0.3	1	3	0	0	1	3	1.0	1.0	0	0
Deep Creek No. 2 ( )	1.2		3		1		3		1.0		0.27
Drayton Harbor No. 1 (11)	1.9	5		14		5		1.0		1.47	
Drayton Harbor No. 2 (12)	1.9	4		0		4		1.0		0	
Dungeness Spit No. 1 (13)	5.4	14	3	6	4	8	3	1.8	1.0	0.08	0.25
Dungeness Spit No. 2 (14)	2.6	10	4	9	1	6	4	1.7	1.0	0.35	0.10
Dungeness Spit No. 3 (15)	2.6	10	4	7	3	6	4	1.7	1.0	0.27	0.29
Dungeness Spit No. 4 (16)	2.2	7	3	2	2	6	3	1.2	1.0	0.13	0.30
Dungeness Spit No. 5 (17)	2.0	7	4	3	4	6	4	1.2	1.0	0.21	0.50
Dungeness Spit No. 6 (18)	4.8	15	2	15	2	9	2	1.7	1.0	0.21	0.21
Green Point No. 1 (19)	0.6	4		2		4		1.0		0.83	
Padilla Bay No. 1 (20)	0.5	5	2	1	0	5	2	1.0	1.0	0.40	0
Padilla Bay No. 2 (21)	0.5	8	11	0	0	7	8	1.1	1.4	0	0
Padilla Bay No. 3 (22)	0.5	4	3	2	1	4	3	1.0	1.0	1.00	0.67
Point Roberts No. 1 (23)	0.9	5	1	16[3]	1	5	1	1.0	1.0	3.56	1.11
Point Roberts No. 2 (24)	1.4	9	3	2	0	8	2	1.1	1.5	0.16	0
Point Roberts No. 3 (25)	0.6	1		0		1		1.0		0	
San Juan No. 1 (26)	1.9	8		1		4		2.0		0.07	
San Juan No. 2 (27)	1.1	2		0		1		2.0		0	
Voice of America (28)	0.9	10		3		7		1.4		0.33	
Mean										0.24	0.28

---

[1] Rate: Number dead birds found per km of beach per census. This unit is independent of time, i.e., week or month. At present, there is no way to calculate the number of dead birds that actually reach a stretch of beach on any unit of time. See text for explanation.

[2] Numbers in parentheses refer to specific numbered locations in Figure 4.

[3] Includes 12 Western Grebes found on 26 August, 1978 that probably died in fishing net.

Table 9. Numbers and species composition of dead birds found on beach walks in 1978 and 1979 (N=110 birds).

Species Group	Percent of Total Number of Birds	Species	Number Found
LOONS	5%		
		Loon Sp.	1
		Common Loon	3
		Arctic Loon	2
GREBES	23%		
		Grebe Sp.	3
		Horned Grebe	2
		Western Grebe	20
PROCELLARIIDS	<1%		
		Northern Fulmar	1
CORMORANTS	<1%		
		Pelagic Cormorant	1
HERONS	2%		
		Great Blue Heron	2
DUCKS	20%		
		Mallard	1
		Green-winged Teal	1
		American Wigeon	1
		Greater Scaup	2
		Scaup Sp.	1
		Bufflehead	7
		White-winged Scoter	1
		Surf Scoter	3
		Scoter Sp.	5
SHOREBIRDS	<1%		
		Pectoral Sandpiper	5
JAEGERS	<1%		
		Parasitic Jaeger	1
GULLS, TERNS	30%		
		Glaucous-winged Gull	22
		Gull Sp.	7
		Herring Gull	1
		California Gull	1
		Mew Gull	1
		Common Tern	1
ALCIDS	15%		
		Common Murre	8
		Marbled Murrelet	1
		Ancient Murrelet	1
		Rhinoceros Auklet	6
OTHER	4%		
		Bird	4
TOTAL			110

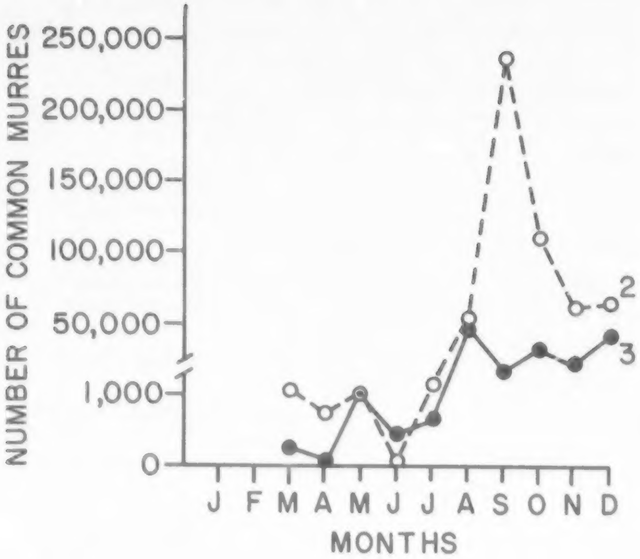

Figure 28. Figure showing the numbers of Common Murres in the Strait of Juan de Fuca during 1978.

high mortality. Such mortality in the study area is now presumed to be mostly caused by disease or parasite infestations or by fish-net kills. Oiled birds were rarely found in 1978 and 1979. Time and personnel limitations did not allow us to conduct extensive beach walks except at a few strategic locations where local volunteers provided regular intensive effort. Data from beach walks indicate that under present conditions, the rate of occurrence varies from 0 to 3.56 dead birds/km/census. These values are generally lower than values obtained in a similar study in 1975-1976 in southern California (K. Briggs, pers. comm.) but there is considerable overlap. The southern California data are presented as the number of dead birds/km/month and are often directly comparable to our data. The mean rate in our study varied from 0.24 in 1978 to 0.28 birds/km/census in 1979. The rates in 1978 and 1979 are not statistically different (Wilcoxon t-test, p=.05).

2. Mortality Rates Derived from Ferries and Aerial Surveys

Dead birds can be easily seen by trained observers from ferries and aircraft, although the cause of death cannot usually be determined. Nevertheless, these data provide a reliable index of dead birds seen floating on the water. Numbers of ferry and aircraft surveys during 1978 and 1979 were seasonally extensive and dead birds observed on these are shown in Tables 10-13. The sightings-rate of floating dead birds is low, similar to the dead-birds-observed rate from the beach walks, with highest numbers found during the fall and winter months.

3. Incidence of Oiled Birds

The incidence of oiling in the study area during 1978 and 1979 was very low, particularly when considering the large volume of shipping traffic and the large number of birds (Tables 14 and 15). Our analysis of the causes of death is inconclusive although we are certain that nearly all the birds examined did not suffer from the direct effects of oil contamination.

If there was a major oil spill, beached bird censuses and airplane/ferry surveys would certainly document the general amount of oiling when compared to the baseline established during this investigation.

I. Natural Variation in Marine Bird Numbers

1. Spatial Variation

Short-term variations in bird numbers are often very great and these have implications for interpreting any census results. Patchiness of prey species (in the case of fish-eating birds), disturbance, and effects of weather often result in large local variations within a brief period of time.

Birds on nesting colonies and roosting rocks left these areas at first sign of daybreak, so numbers observed during our mid-day censuses usually represented only a fraction of the birds actually using these sites at night. The effect of this variation is to underestimate numbers actually using colonies and roosts. We attempted to take this into account when rating these

Table 10. Characteristics of ferry-shoreline dead bird transects and numbers of dead birds observed, 1978-1979.

Season	Transect Length (km)	Total Area (km^2)	Birds/km	Birds/km^2
Winter 1978	144.3	77.4	.0069	.0129
Spring 1978	119.0	68.4	0	0
Summer 1978	15.8	13.0	0	0
Fall 1978	141.2	108.7	0	0
Winter 1978-1979	215.9	122.9	0	0
Spring 1979	108.1	93.3	0	0
Summer 1979	57.5	50.5	0	0
Fall 1979	167.5	148.6	.0059	.0067
Winter 1979	185.4	68.3	.0054	.0146

Table 11. Characteristics of ferry-open water dead bird transects and numbers of dead birds observed, 1978-1979.

Season	Transect Length (km)	Total Area (km^2)	Birds/km	Birds/km^2
Winter 1978	617.6	355.5	0	0
Spring 1978	792.9	534.5	0	0
Summer 1978	491.2	359.0	0	0
Fall 1978	986.9	743.9	.0071	.0091
Winter 1978-1979	1,417.2	822.0	.0093	.0160
Spring 1979	562.1	475.6	0	0
Summer 1979	277.2	234.6	0	0
Fall 1979	1,147.7	1,015.7	0	0
Winter 1979	558.6	521.8	0	0

Table 12. Characteristics of aerial-shoreline dead bird transects and numbers of dead birds observed, 1978-1979.

Season	Transect Length (km)	Total Area (km^2)	Birds/km	Birds/km^2
Winter 1978	883.9	83.9	0	0
Spring 1978	1,709.9	191.3	0	0
Summer 1978	404.1	54.4	0	0
Fall 1978	1,275.4	157.3	.0047	.0380
Winter 1978-1979	1,661.6	239.5	.0012	.0083
Spring 1979	796.5	111.1	0	0
Summer 1979	418.3	57.5	0	0
Fall 1979	810.7	113.0	0	0
Winter 1979	418.6	66.5	.0047	.0300

Table 13. Characteristics of aerial-open water dead bird transects and numbers of dead birds observed, 1978-1979.

Season	Transect Length (km)	Total Area (km^2)	Birds/km	Birds/km^2
Winter 1978	812.2	83.4	0	0
Spring 1978	1,076.9	120.6	.0018	.0165
Summer 1978	393.1	70.2	0	0
Fall 1978	1,205.3	144.6	.0041	.034
Winter 1978-1979	1,775.0	232.3	.0011	.014
Spring 1979	1,119.9	135.4	0	0
Summer 1979	524.4	69.8	0	0
Fall 1979	1,079.7	144.3	.0009	.0069
Winter 1979	643.8	74.7	0	0

Table 14. Water and beach conditions of census locations where dead birds were found in 1978 and 1979.

Water	Year	
	1978	1979
No oil	58%	57%
Thin oil slick	2	0
Fish oil slick	1	12
Unknown slick	1	3
Unknown	36	27
Beach		
No oil	77	73
Unknown	23	27

Table 15. Amount of oiling and cause of death of birds found on beach walks.

	1978 (N=72)	1979 (N=33)
Oiling		
No oil	57%	27%
Trace of oil	1	0
Unknown	43	73
Cause of Death		
Gunshot	<1	3
Bacterial	<1	0
Trauma	0	6
Predation	0	18
Unknown	99	73

areas, particularly by using nest counts in the case of breeding birds or sea watch observations of birds leaving roosts. This allowance is especially important when burrow-nesting species are present. Projected summer populations based on birds observed during regular aircraft or boat censuses at Protection Island, for example, represent only about 20% of the actual breeding population on the island. Of course at least some of these birds might well have been censused later while they were foraging or at day-roost areas, and this demonstrates the importance of foraging areas away from colonies and roosts. In July 1979 we estimated about 33% of the Rhinoceros Auklet population--almost all based at Protection Island--were foraging simultaneously in Admiralty Inlet (Figure 26).

Some indications of hourly variation were evident from replicate samples. The Admiralty Inlet ferry route between Keystone, Whidbey Island, and Port Townsend was normally censused in both directions, round-trip, within a period of about 1.5 hours. Strong tidal currents were usually present there, and feeding birds censused within transect width on one crossing often drifted well out of transect on the return. This obvious, drifting "patchiness" in distribution resulted in large variations in numbers observed, densities, and subsequent estimates. Variation observed for the most abundant species during the Admiralty Inlet crossings is clearly shown in Table 16.

Table 16. Variation in birds/km^2 observed in replicate transects on the Admiralty Inlet Ferry in 1979.

Species	Number of Replicates	Range of Variation (no. of birds)	S.D.
Gulls	10	0-107	29.1
Common Murre	7	0-62	15.7
Rhinoceros Auklet	8	0-114	42.5
All Species	10	6-192	75.5

We also replicated censuses from shore locations during the course of a brief Rhinoceros Auklet distribution survey in July 1979. These counts represented birds censused in a complete scan from a fixed point during a reasonably brief period of time. All birds, including those in flight, were included. Many birds passed these locations (Point Wilson, Table 17, and Green Point, Table 18) on their way to feeding areas, and other birds foraged in tide rips within the area. Data in Tables 17 and 18 show how the time of day may affect census results.

Table 17. Variation in numbers of seabirds observed during 15 point censuses at Pt. Wilson, 13 July 1979.

Species	Total Birds Censused	Range of Variation (no. of birds)	Mean Variation	Hour of Max. Census Count
Cormorants	6	0-1	0.4	---
Large Gulls	796	0-132	53.0	0700
Bonaparte's Gulls	117	0-44	7.8	0504
Pigeon Guillemot	28	0-11	1.9	1600
Marbled Murrelet	2	0-2	0.1	0800
Rhinoceros Auklet	744	0-277	49.6	0917
All Species	1,784	0-309	118.9	0917

Table 18. Variation in numbers of seabirds observed during 17 point censuses at Green Point, Anacortes, 14 July 1979.

Species	Total Birds Censused	Range of Variation (no. of birds)	Mean Variation	Hour of Max. Census Count
Cormorants	46	0-25	2.7	1900
Large Gulls	163	0-107	9.6	0920
Bonaparte's Gull	84	0-25	4.9	0700
Pigeon Guillemot	9	0-3	0.5	1010
Marbled Murrelet	74	0-12	4.4	0920, 1655
Rhinoceros Auklet	84	0-20	4.9	0920
All Species	467	0-153	27.5	0920

2. Temporal Variations

There are natural variations in seabird populations on an annual, seasonal, and daily basis. Patchiness and mobility of birds and their prey make the measurement of these variations difficult. Census results will vary by time of day, stage of tide, weather, and feeding opportunities. Numbers observed will vary from day to day and week to week, even during relatively "stable" periods like mid-winter or during the nesting season.

Over a short-term study such as this, annual comparisons are difficult. Nevertheless, our data indicate that large variations in numbers are probably typical of marine bird populations in the study area. When the 1979 projected total numbers for the subregions are compared with 1978 numbers, only 13% of the comparisons show 10% less variation between years (Table 19). Of the three seasons tested, the largest population changes occur in the summer when the 1979 population mean was 186% of the 1978 population. This may reflect the influence of a late spring migration, an early fall migration, or larger numbers of nonbreeding northern birds present in the area in 1979. More analysis is required to explain the large difference in numbers between years.

In general, birds were concentrated in the same areas during both years of this study, although absolute numbers showed some dramatic annual variation (Table 19 and Appendices D and E).

Seasonal variations are clearly evident, at least in broad-scale terms (i.e., see Figures 22 and 23). In 1979 largest numbers of Western Grebes and Common Murres entering the study area for the winter appeared to arrive about two weeks later than in 1978. Measurement of daily variations were often quite difficult for any but the most sedentary species (see Tables 17 and 18). This was due to local conditions of weather (affecting both bird distribution and conditions of observation), feeding opportunities, and displacement due to disturbance.

Accurate measurement of seasonal movements could require at least weekly censusing. It should also be emphasized that we cannot say whether our censuses were taken during high, "average," or low points on long-term natural population cycles. While some studies have indicated long-term increases in some gulls (Drury 1973), there were few data regarding such trends for most species or total populations in our study area. Therefore, frequent censusing is necessary to document the natural cycles of annual, seasonal, and daily variation.

J. Species-level Discussion

1. Major Species

We observed a total of 116 species during this two-year study (see Appendix Table C-5). Throughout this study, however, we have most often discussed birds as family groups rather than on a species level. There are several species which make up significant, specialized members of the populations using the Washington inland marine ecosystem. They are discussed below

Table 19. Annual variation in bird numbers in subregions of the study area; 1979 is compared with 1978.*

Subregion		Season	
	Spring	Summer	Fall
0201	201		109
0202	100†		
0203	178		70
0204	72		
0205	282		267
0206	129	177	123
0207	64	107	310
0208	67		235
0209	54		176
0301	171	561	258
0302	110	560	261
0303	109	126	100
0304	52	113	106
0305	97		56
0306	113	179	84
0307	82		30
0308	121		59
0309	107		147
0310	171		113
0311	148		139
0312	144		97
0313			246
0314	84		302
0315	86	39	66
0316	43		54
0317	44		50
0401	223		263
0501	53		24
0502	38		
0503	65	79	92
0504	89		44
0505	115		29
0506	225	204	26
0507	210	367	169
0601	39		165
0602	58	159	114
0603	63		93
0604	75		68
0605	178	173	93
0606			
0607	262		104
0608	354		88

Table 19. (continued)

Subregion	Spring	Season Summer	Fall
0701	83	278	143
0702	17	29	41
0703	166	75	74
0801	218	70	81
0802	71		68
0901	117	160	25
0902	121		35
0903	112	163	24
1001	93		193
1002	29		221
1101	117		50
1102			71
1103	53		102
1104	47		110
1105	53		74
1106	100		78
1108	186	94	96
1201	169	491	17
1202	400	700	61
1203	283		
1210			48
1301	52	123	117
1302	100	42	54
1303	143	7	119
Mean	117	186	109
S.D.	71	161	76
N=	62	23	60

---

*A value of 100 means that the projected total numbers for 1978 and 1979 were identical. Values below 100 means that there were fewer birds in 1979 compared with 1978.

†Values underlined are <10% above or below the 1978 projected total.

in Appendix K-I in order to (1) highlight specific problems, and (2) to generally illustrate their vulnerability to human activities. We have not discussed many species (such as gulls and Mallards) which apparently easily adapt to changes caused by humans. Several of these adaptable species have received protection through "management" (game species) and we feel these do not presently require special treatment in the species accounts below. Our discussions attempt to highlight the species present status within the study area. The "Blue List" designation is applied by the National Audubon Society to "species recently or currently giving indications of noncyclical population declines or range contractions, either locally or widespread" (Arbib 1979). This designation serves as an early warning that the species may become "threatened." This status is applied at three classes: I. widespread species with widespread support (by regional observers) for inclusion as Blue-listed; II. species with more restricted range; III. marginally designated species.

2. Additional Species

Many other species using the area are of interest and concern. They are not numerous. Several are very localized while in the study area or quite specialized in habitat requirements, and several are designated as endangered or are on the Blue List at the continental level (Appendix K-II). These include various swans, geese, ducks, shorebirds, gulls, and terns which are important components of the avifauna and are vulnerable as individuals. Further, the Bald Eagle is an important predator/scavenger within the study area, and the Peregrine Falcon occurs regularly but in relatively small numbers. These species are often only peripherally involved with the water and shore edge, yet there is no doubt that they are part of the overall food chain dynamics. Populations of the Bald Eagle and Peregrine Falcon in our study area are probably larger than in other marine ecosystems in populated North America. They would certainly, and likely seriously, be affected by major oil spills. We discuss them briefly in Appendix K in order to update their status based on our two-years' field work in the study area.

VI. GEOGRAPHICAL AREAS OF VULNERABILITY

A. Data Base Development

The projected total seasonal marine bird populations for each of the 68 subregions (Appendices G, H and I) reveal a measure of the significance of a particular location. From another perspective, the BOI values (Appendices G, H and I) reflect the vulnerability of the species mix of any particular subregion.

Each subregion was rated in terms of both BOI and BOI/km^2 (Appendix J). We averaged these ratings and ranked each subregion in one of five rankings (Table 20). The averaged rating intervals for each rank are 1:0-2; 2:>2-5; 3:>5-7; 4>7-10; and 5:>10, with 5 being the highest rank. Rankings represent averaged conditions observed in 1978 and 1979. Subregions with a rank of 5 are those in which birds were highly abundant, very important to the total population in the area, and primarily occupied by species susceptible to the effects of oil. Subregions with a rank of 1 are those in which few vulnerable species are present.

A subregion's rank was increased by one if it contained significant nesting colonies, roosting sites, or foraging areas, the values of which could not be reflected through regular census methods. The seasonal subregion rankings for each region are displayed in Figures 29-38.

Distribution, behavior, mortality, and variation in bird numbers (discussed in V, above) also influence subregional ratings. In addition, we point out that there is daily interchange between subregions and interpretation of ratings, derived from data acquired in mid-day, may be biased. We also stress that these ratings were derived from seasonally averaged population projections. Evaluation of biological habitats should properly be based on maximum annual use, and our projections are thus quite conservative. Differences in projected totals and BOI values between high and low-ranked subregions would be much greater if maximum numbers were used.

B. Subregions of Importance

Those termed "significantly important" are subregions with a seasonal ranking of 5 (Table 20 and Appendix Tables J-1 and J-2). Those termed "highly important" are those subregions with a seasonal ranking of 4.

Table 20. Seasonal rankings of the subregions of the study area, 1978/1979.

Subregion Code	Name	Season			
		Spring	Summer	Fall	Winter
0201	Strait of Juan de Fuca-Outer	3	2	5	4
0203	Cape Flattery	(4)[1]	(3)	4	3
0204	Neah Bay	2	2	2	2
0205	Neah Bay to Clallam Bay	2	(3)	3	2
0206	Clallam Bay	2	2	2	2
0207	Clallam Bay to Crescent Bay	2	(3)	3	2
0208	Crescent Bay	2	2	2	2
0209	Crescent Bay to Ediz Hook	2	2	3	4
0301	Strait of Juan de Fuca-Inner	3	3	5	4
0302	Ediz Hook	1	1	2	1
0303	Port Angeles	2	(3)	2	2
0304	Voice of America	2	2	3	2
0305	Dungeness Spit	2	2	3	3
0306	Dungeness Bay/Harbor	4	2	3	3
0307	Jamestown	[5][2]	[5]	4	[5]
0308	Sequim Bay	2	1	2	2
0309	Miller Peninsula	2	2	2	3
0310	Protection Island	4	5	4	3
0311	Discovery Bay	3	1	2	4
0312	Quimper Peninsula	2	3	4	4
0313	Whidbey Island	1	2	3	2
0314	Smith Island	3	[(5)]	4	3
0315	Deception Pass	2	2	2	2
0316	Lopez Island (south shore)	[5]	(4)	4	3
0317	San Juan Island (south shore)	2	2	3	2
0401	Admiralty Inlet	3	[5]	[5]	2
0501	Bellingham Channel	2	(3)	4	4
0502	Guemes Channel	2	2	1	[3]
0503	Fidalgo Bay	2	1	2	3
0504	Padilla Bay	5	(3)	4	5
0505	Samish Bay	5	2	4	5
0506	Bellingham Bay	4	2	4	5
0507	Hale Passage	[3]	2	2	2
0601	Lummi Bay	5	2	3	4
0602	Cherry Point	5	2	2	2
0603	Birch Bay	4	2	3	3
0604	Semiahoo Spit	4	3	4	4
0605	Drayton Harbor	3	(3)	3	4
0607	San Juan Islands-Northern Tier	3	(2)	2	4
0608	Georgia Strait-Eastern	4	2	4	4
0701	Pt. Roberts	4	2	2	4
0702	Tsawwassen Bay	4	2	2	3
0703	Georgia Strait-Western	2	2	2	2
0801	Northern Haro Strait	2	(3)	4	3
0802	Southern Haro Strait	1	1	1	2
0901	Southern Rosario Strait	[3]	(3)	[3]	[5]
0902	Central Rosario Strait	[3]	(2)	[5]	[4]
0903	Northern Rosario Strait	[5]	(4)	[5]	[4]
1001	President Channel	2	(2)	2	2
1002	Northern Areas	1	2	2	3
1101	Speiden Channel	1	1	2	2
1102	Northern San Juan Channel	1	1	1	1
1103	Southern San Juan Channel	1	[5]F	2	3
1104	Wasp Pass	1	1	1	2
1105	Upright Channel	1	2	2	2
1106	Harney Channel	1	1	1	2
1107	Obstruction Pass	2	1	3	2
1108	Thatcher Pass	1	1	1	1
1201	Mosquito/Roche Complex	2	2	2	3
1202	Friday Harbor	2	1	2	2
1203	Griffin Bay	2	2	2	3
1205	Fisherman Bay	2	2	2	3
1206	Swifts/Shoal Bays	2	(2)	2	2
1207	Deer Harbor	2	1	2	2
1208	West Sound	1	1	2	2
1209	East Sound	2	1	1	2
1210	Lopez Sound	2	2	3	4

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[1] ( ) Breeding colony effect.

[2] [ ] Concentrations, roosting, local movement, foraging.

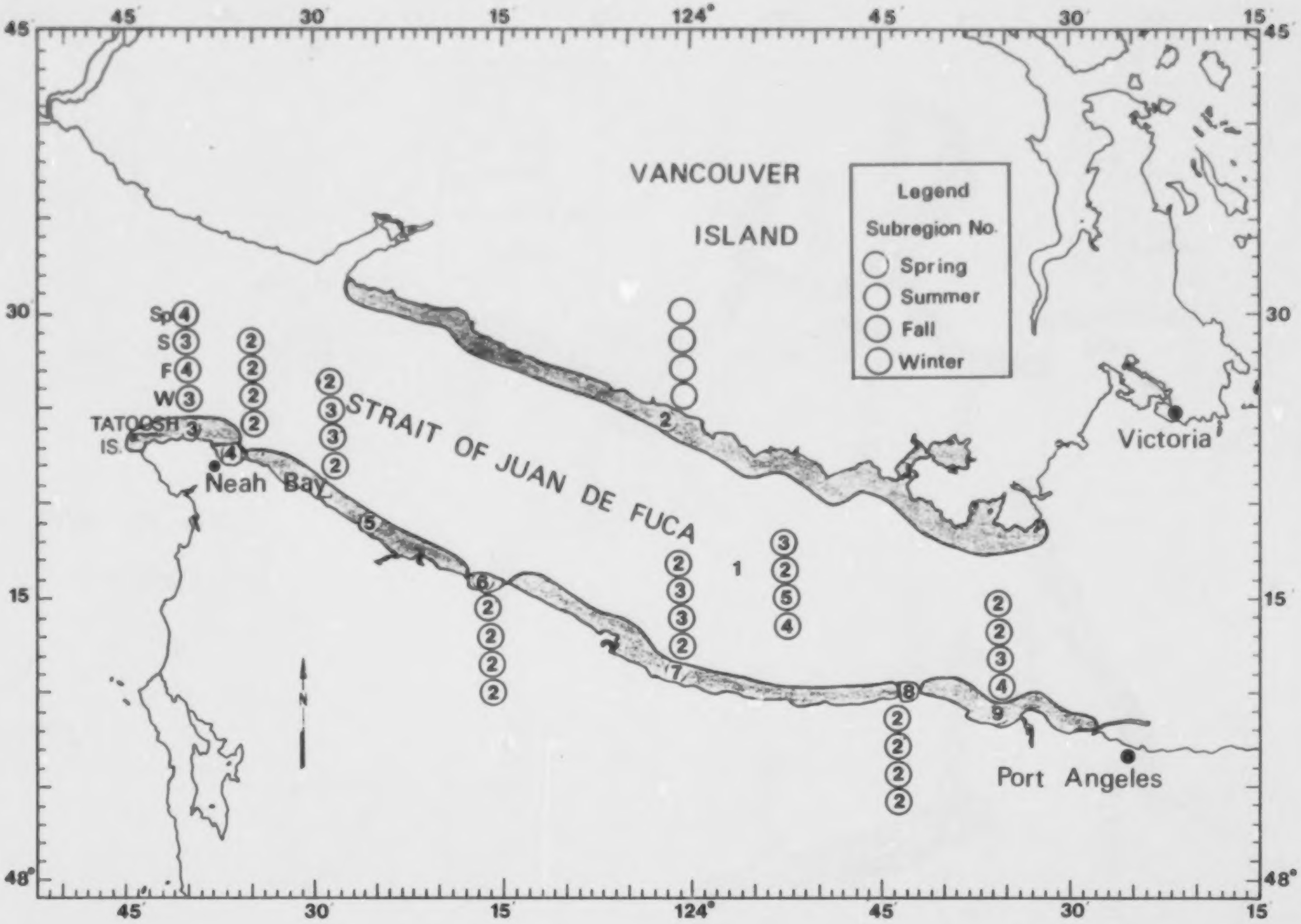

VANCOUVER
ISLAND
Legend
Subregion No.
Spring
Summer
Fall
Winter
STRAIT OF JUAN DE FUCA
TATOOSH IS.
Neah Bay
Victoria
Port Angeles
Sp ④
S ③
F ④
W ③
1
2
3
④
⑤
⑥
7
⑧
9
45
30
15
124°
48°

Figure 29. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the Strait of Juan de Fuca, Outer region, region no. 2.

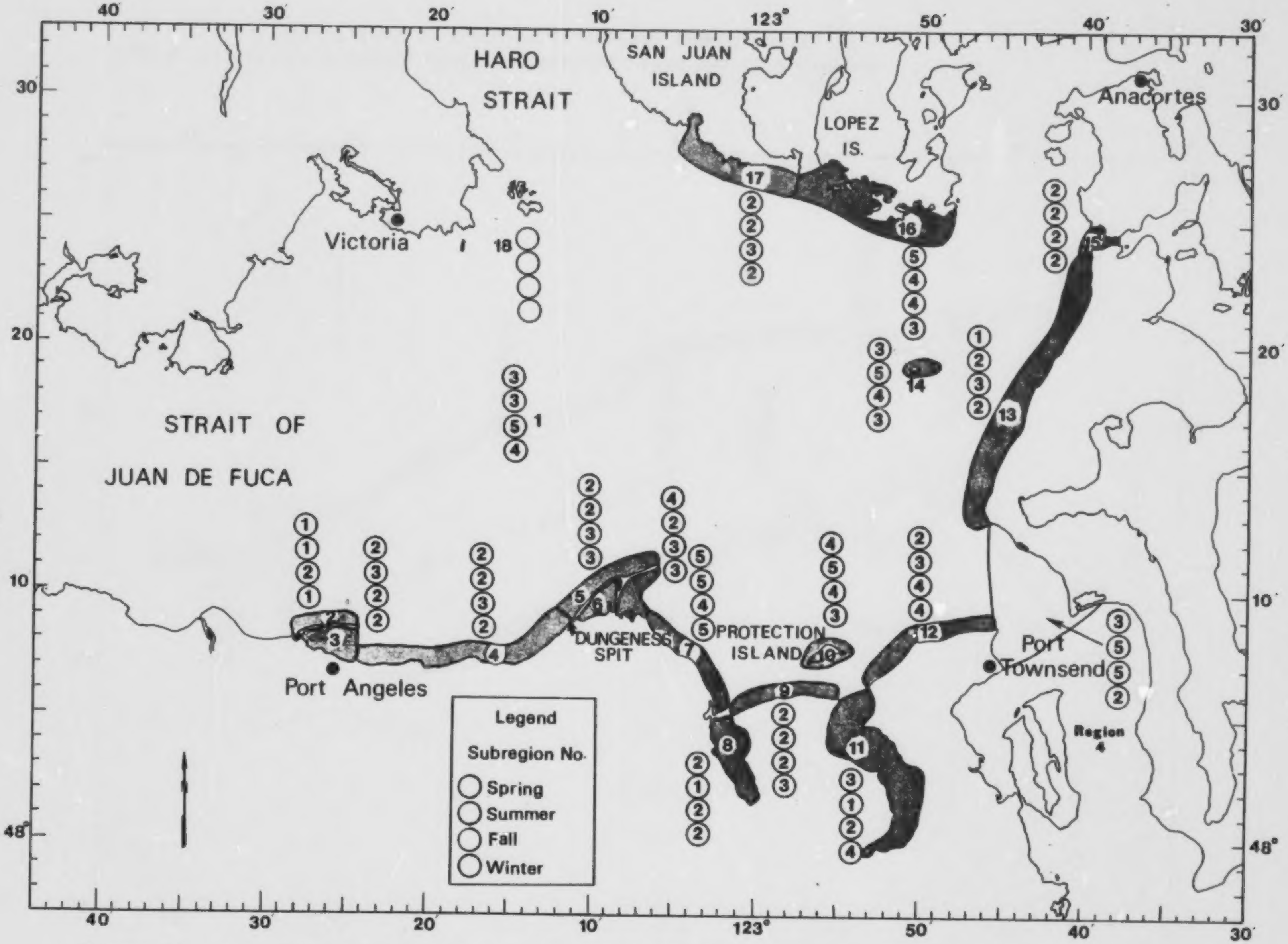

HARO STRAIT
SAN JUAN ISLAND
LOPEZ IS.
Anacortes
Victoria
STRAIT OF JUAN DE FUCA
Port Angeles
DUNGENESS SPIT
PROTECTION ISLAND
Port Townsend
Region 4
Legend
Subregion No.
Spring
Summer
Fall
Winter
123°
50'
40'
30'
20'
10'
48°

Figure 30. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the Strait of Juan de Fuca, Inner region, region no. 3, and Admiralty Inlet region, region no. 4.

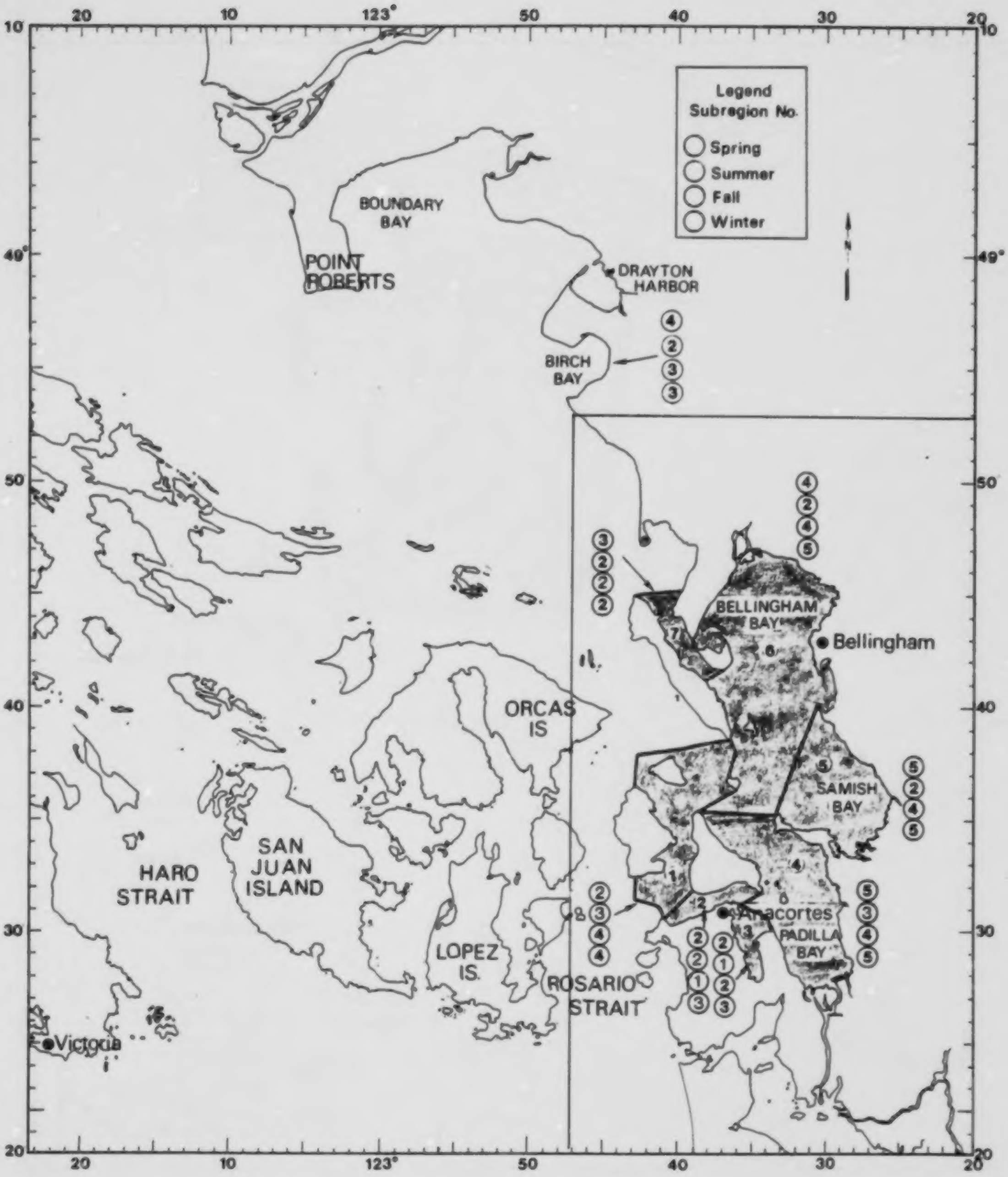

Legend
Subregion No.
○ Spring
○ Summer
○ Fall
○ Winter
N
BOUNDARY BAY
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
④ ② ③ ③
④ ② ④ ⑤
③ ② ② ②
BELLINGHAM BAY
Bellingham
ORCAS IS
SAMISH BAY
⑤ ② ④ ⑤
HARO STRAIT
SAN JUAN ISLAND
LOPEZ IS.
ROSARIO STRAIT
Anacortes
PADILLA BAY
② ③ ④ ④
② ② ① ③
② ① ② ③
⑤ ③ ④ ⑤
1
2
3
4
5
6
7
8
Victoria
10
20
10
123°
50
40
30
20
49°
50
40
30
20

Figure 31. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the Anacortes to Hale Passage region, region no. 5.

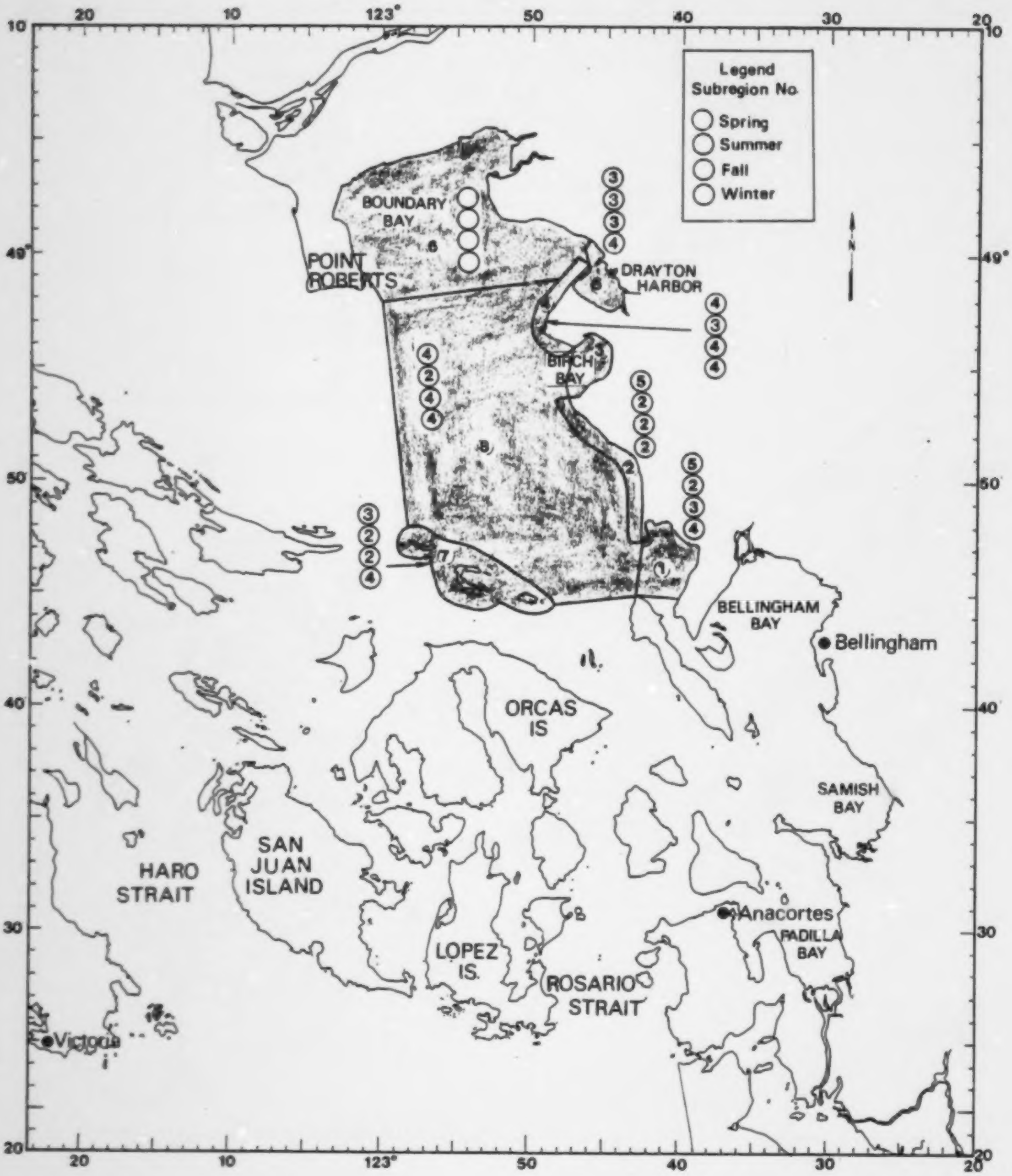
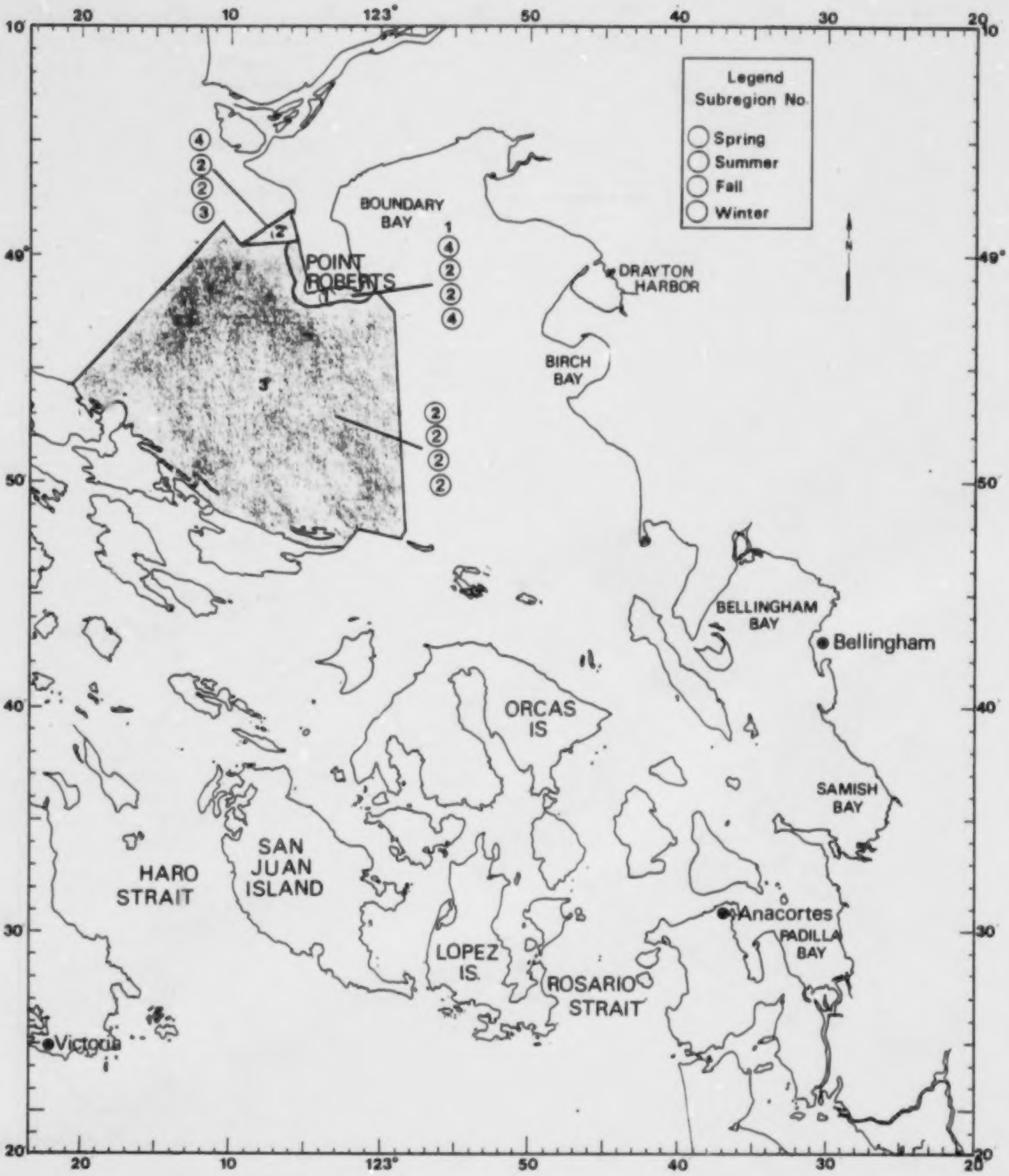

Legend
Subregion No.
Spring
Summer
Fall
Winter
BOUNDARY BAY
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
BELLINGHAM BAY
Bellingham
ORCAS IS
SAMISH BAY
SAN JUAN ISLAND
HARO STRAIT
LOPEZ IS.
ROSARIO STRAIT
Anacortes
PADILLA BAY
Victoria
123°
49°
50
40
30
20
10

Figure 32. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the Georgia Strait, Eastern region, region no. 6.



20
10
123°
50
40
30
20
10
49°
50
40
30
20
Legend
Subregion No.
○ Spring
○ Summer
○ Fall
○ Winter
N
④
②
②
③
2
BOUNDARY BAY
1
④
②
②
④
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
3
②
②
②
②
BELLINGHAM BAY
Bellingham
ORCAS IS
SAMISH BAY
SAN JUAN ISLAND
HARO STRAIT
LOPEZ IS.
ROSARIO STRAIT
Anacortes
PADILLA BAY
Victoria

Figure 33. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the Georgia Strait, Western region, region no. 7.

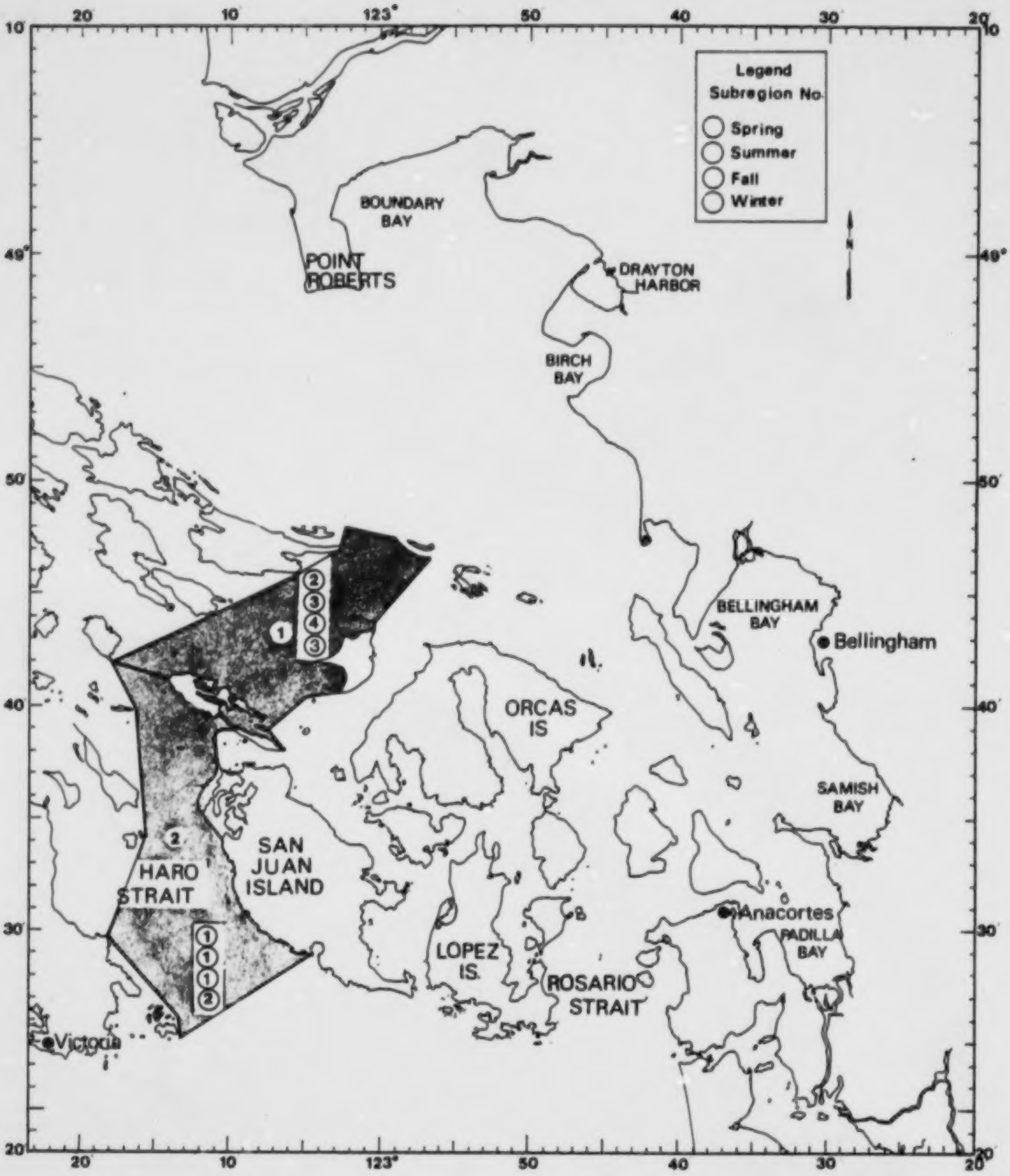

20
10
123°
50
40
30
20
10
49°
50'
40'
30'
20
Legend
Subregion No.
Spring
Summer
Fall
Winter
N
BOUNDARY BAY
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
BELLINGHAM BAY
Bellingham
ORCAS IS
SAMISH BAY
SAN JUAN ISLAND
HARO STRAIT
Anacortes
PADILLA BAY
LOPEZ IS.
ROSARIO STRAIT
Victoria
1
2
3
4
3
2
1
1
1
2

Figure 34. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the Haro Strait region, region no. 8.

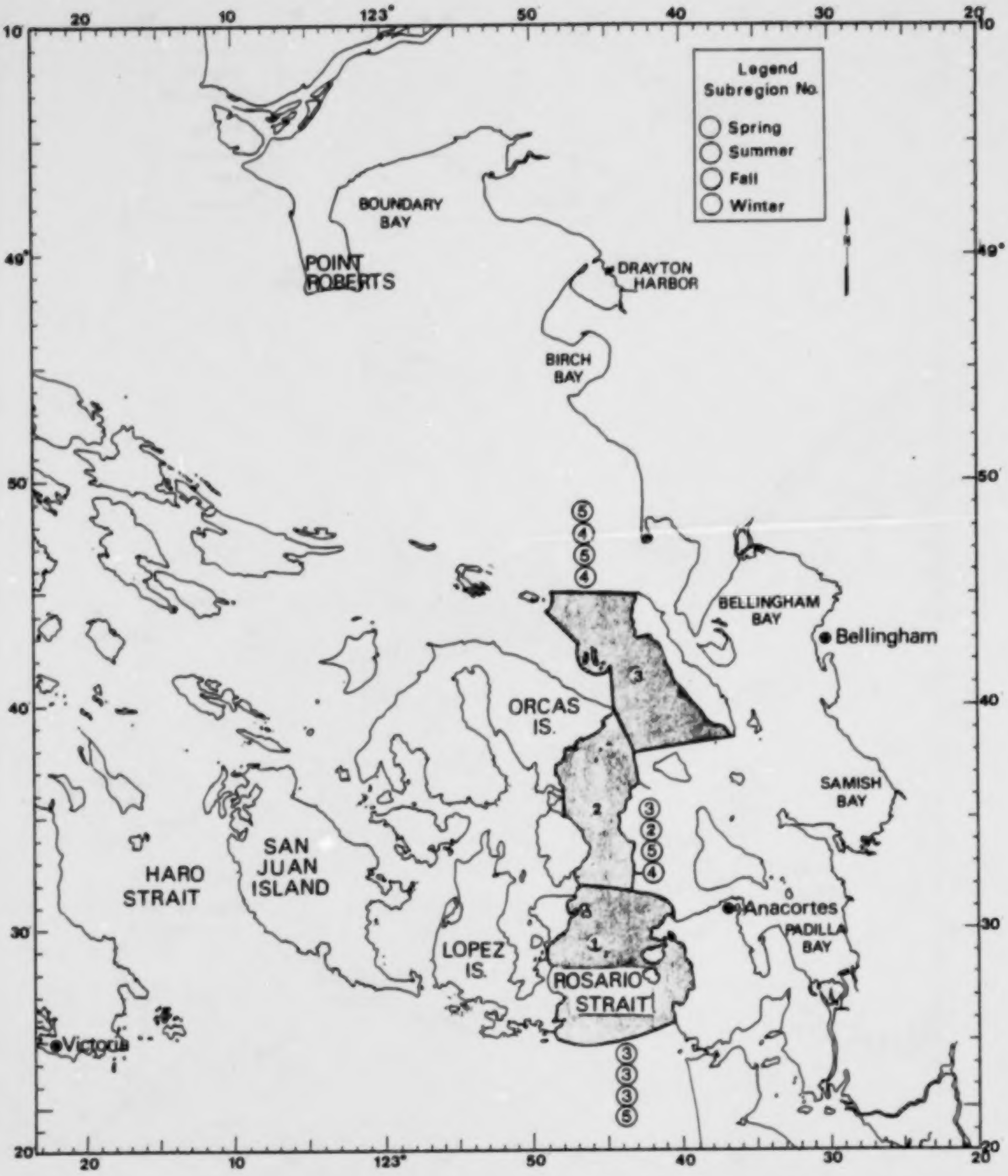

20
10
123°
50
40
30
20
10
49°
50
40
30
20
Legend
Subregion No.
○ Spring
○ Summer
○ Fall
○ Winter
BOUNDARY BAY
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
BELLINGHAM BAY
Bellingham
ORCAS IS.
SAMISH BAY
HARO STRAIT
SAN JUAN ISLAND
LOPEZ IS.
Anacortes
PADILLA BAY
ROSARIO STRAIT
Victoria
⑤
④
⑤
④
3
2
③
②
⑤
④
1
③
③
③
⑤

Figure 35. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the Rosario Strait region, region no. 9.

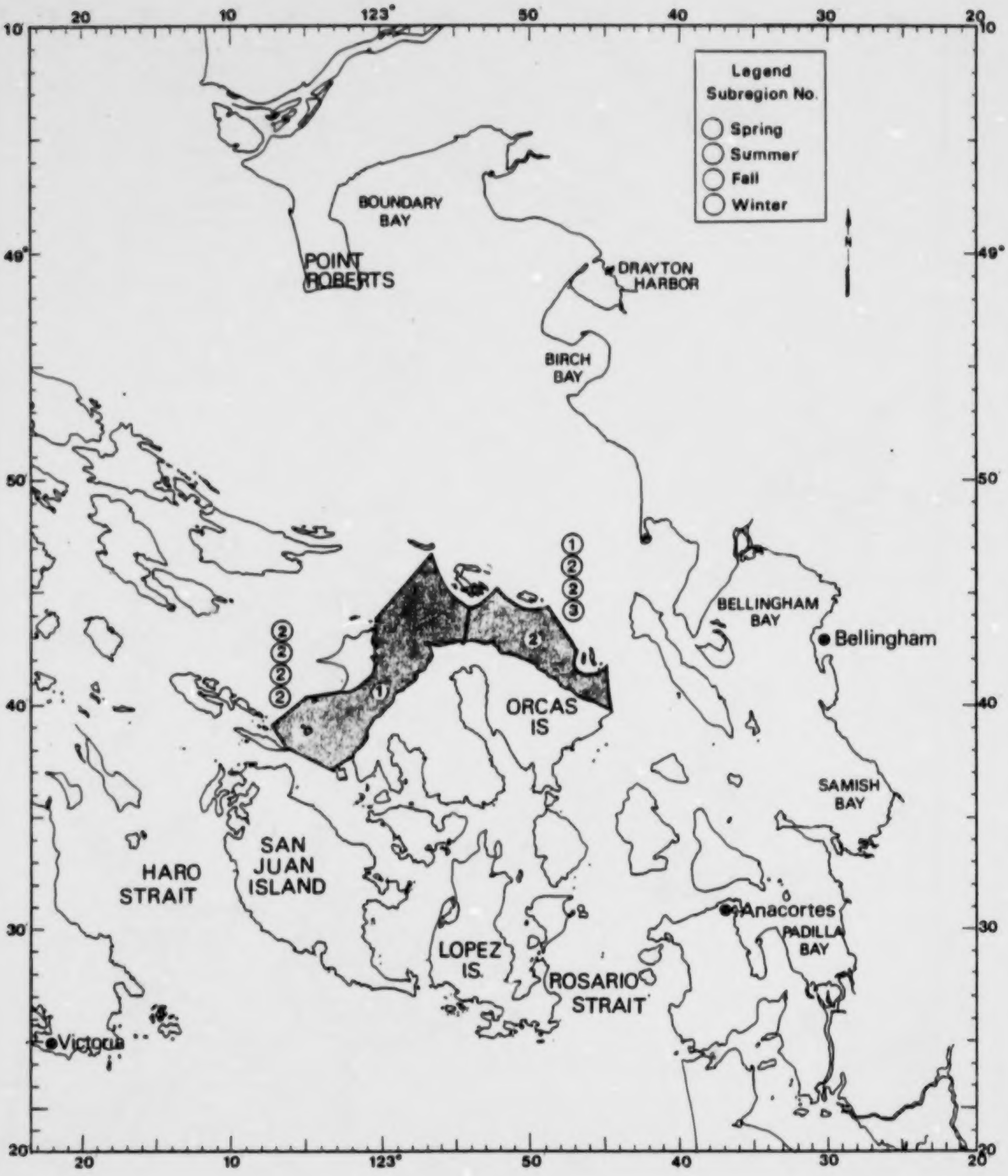
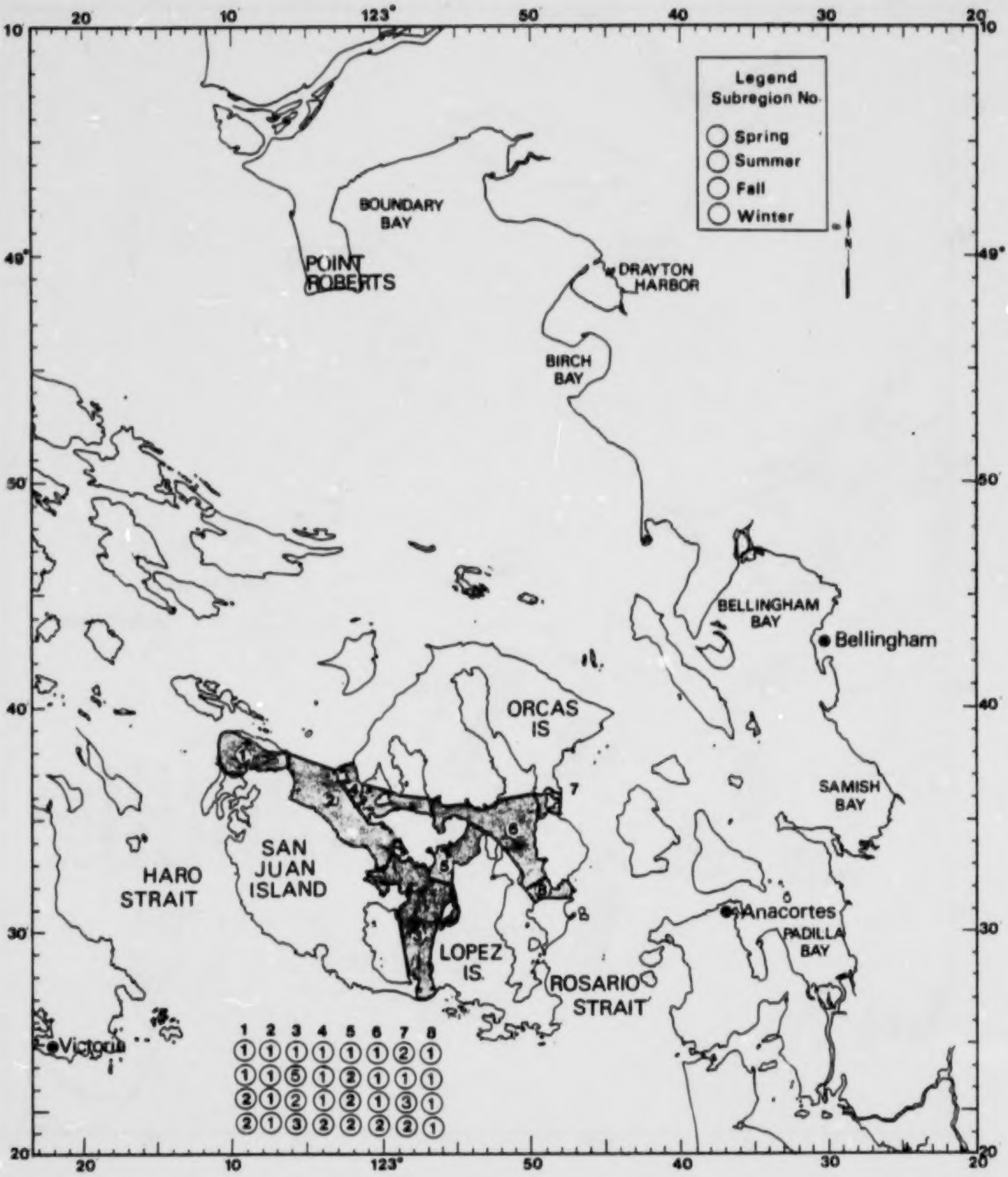

Legend
Subregion No.
○ Spring
○ Summer
○ Fall
○ Winter
BOUNDARY BAY
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
BELLINGHAM BAY
Bellingham
ORCAS IS
SAMISH BAY
SAN JUAN ISLAND
HARO STRAIT
Anacortes
PADILLA BAY
LOPEZ IS.
ROSARIO STRAIT
Victoria
①
②
②
③
②
②
②
②
1
2
20
10
123°
50
40
30
20
10
49°
50
40
30
20
N

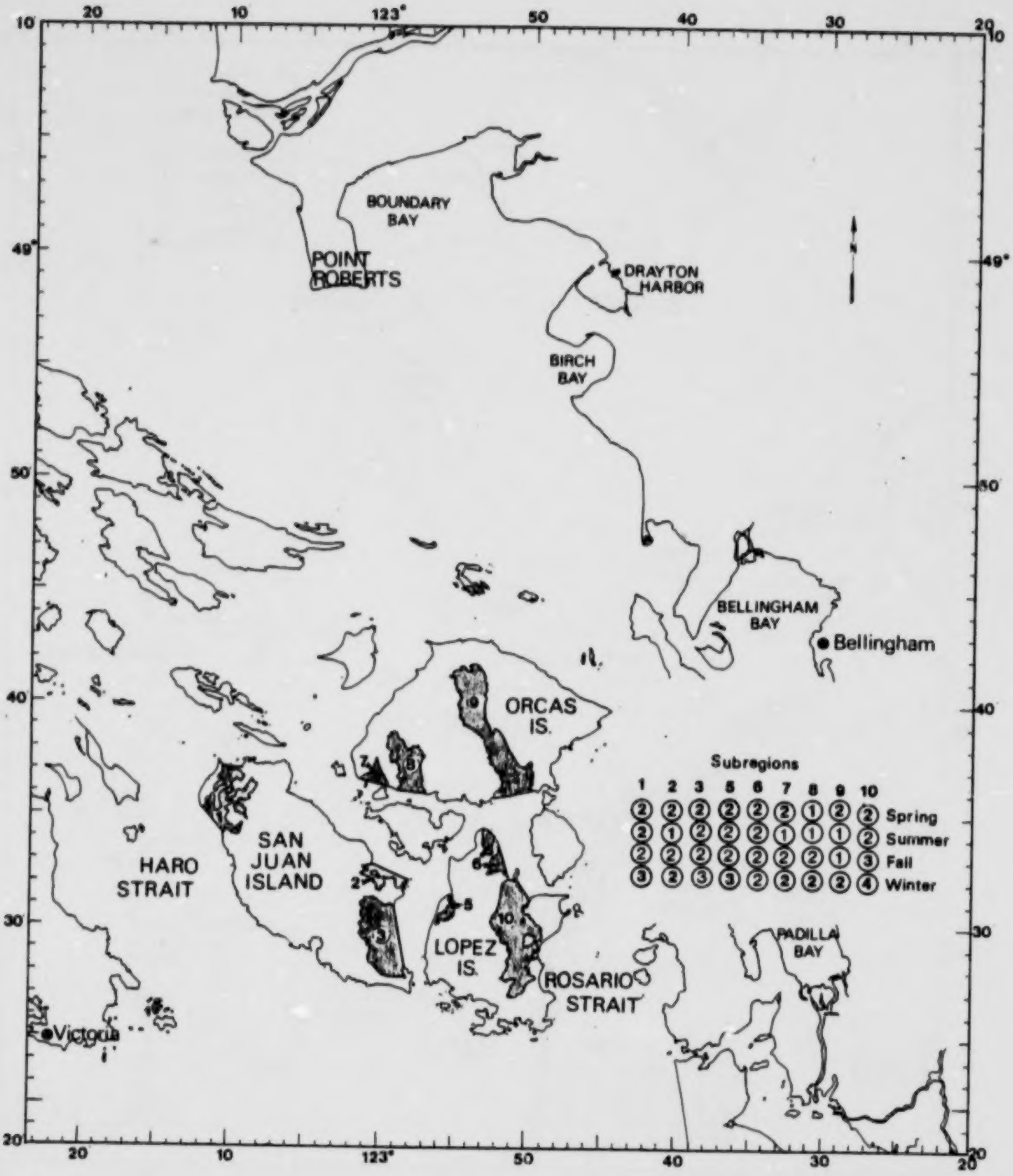
Figure 36. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the San Juan Islands, Northern Waters region, region no. 10.



20
10
123°
50
40
30
20
10
49°
50
40
30
20
Legend
Subregion No.
○ Spring
○ Summer
○ Fall
○ Winter
N
BOUNDARY BAY
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
BELLINGHAM BAY
Bellingham
ORCAS IS
SAMISH BAY
SAN JUAN ISLAND
HARO STRAIT
LOPEZ IS.
ROSARIO STRAIT
Anacortes
PADILLA BAY
Victoria
5
6
7
8

1	2	3	4	5	6	7	8
①	①	①	①	①	①	②	①
①	①	⑤	①	②	①	①	①
②	①	②	①	②	①	③	①
②	①	③	②	②	②	②	①

Figure 37. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the San Juan Islands, Interior Channels and Passages region, region no. 11.


20
10
123°
50
40
30
20
10
49°
50'
40'
30'
20
BOUNDARY BAY
POINT ROBERTS
DRAYTON HARBOR
N
BIRCH BAY
BELLINGHAM BAY
Bellingham
ORCAS IS.
SAN JUAN ISLAND
HARO STRAIT
LOPEZ IS.
ROSARIO STRAIT
PADILLA BAY
Victoria
1
2
3
4
5
6
7
8
9
10

Subregions

1	2	3	5	6	7	8	9	10	
②	②	②	②	②	②	①	②	②	Spring
②	①	②	②	②	①	①	①	②	Summer
②	②	②	②	②	②	②	①	③	Fall
③	②	③	③	②	②	②	②	④	Winter

Figure 38. Seasonal subregional BOI rankings, 1978 and 1979 combined, for the San Juan Islands, Interior Bays and Harbors region, region no. 12.

1. Significantly Important Subregions

The areas described below (graphically presented in Figure 39) are rated as Significantly Important because of high seasonal bird populations and vulnerability to oil spill impacts. These areas fall into two types.

The first type of area includes easily definable geographic units such as bays, specific lengths of shoreline, or island habitats. These lend themselves easily to planning, management, and protection.

The second type is essentially large, open bodies of water which do not lend themselves to the usual concepts of geographic management. We emphasize they still must be considered in the protection of marine birds. Vulnerable birds using these large areas of the Strait of Juan de Fuca and Admiralty Inlet are specialized feeders, often occurring in large flocks, and usually have a patchy distribution associated with tidal convergence areas. These types of areas that are high in importance and vulnerability are briefly described below (see also Table 20). There are other areas adjacent to the study area that we rate as being "significantly important." These decisions are based on published accounts of birds there and on our own observations.

a. Tatoosh Island. More species breed on Tatoosh Island than at the inland colonies to the east. This island is typical of colonies found along the outer coast of Washington where the birds feed primarily in the offshore waters. Tatoosh Island, like many breeding colonies in the study area, has suffered from continual human disturbance. The island has been relatively free from disturbance only recently. The Glaucous-winged Gull is the most abundant species nesting on Tatoosh, with about 2,000 pairs present (Table 5). Five nesting species are extremely vulnerable to effects of catastrophic oil spills. These are the Common Murre, Pigeon Guillemot, Cassin's Auklet, Rhinoceros Auklet, and Tufted Puffin. Two of these--the Murre and Cassin's Auklet--and two other pelagic species, the Fork-tailed and Leach's Storm-petrels, nest nowhere else in the study area. Percentages of study area nesting populations nesting here are given in Table 21. The island is also used as a roosting site for several thousand gulls during the summer months, and by lesser numbers of birds at other times of the year.

b. Open Waters of the Strait of Juan de Fuca. This large area ranks very high in vulnerability almost completely due to the seasonal presence of the Common Murre. The vast numbers of murres that are found in the Strait of Juan de Fuca at various seasons are composed of migrants and winter residents. These birds comprise a large percentage of the avian standing crop biomass in the Strait of Juan de Fuca. Table 22 gives average seasonal percentages of study area populations of murres in the offshore waters in the Strait of Juan de Fuca. These percentages are only partly indicative of the importance of the Strait since virtually all Common Murres enter the study area through the Strait of Juan de Fuca. The projected totals from which these percentages were derived are mean averages over several months, not seasonal peaks (see Appendix K). This species and the Rhinoceros Auklet are offshore inhabitants in the study area and are highly vulnerable to oiling and

Table 21. Tatoosh Island: importance to nesting birds in study area.

Nesting Species	Percentage of study area nesting population
Fork-tailed Storm-Petrel	100
Leach's Storm-Petrel	100
Pelagic Cormorant	19
Black Oystercatcher	6
Glaucous-winged Gull	14
Common Murre	100
Pigeon Guillemot	2
Cassin's Auklet	100
Rhinoceros Auklet	2
Tufted Puffin	55
Total All Species	10

Table 22. Average seasonal percentages of study area Common Murre populations in the offshore components of the Strait of Juan de Fuca (Subregions 0201 and 0301).*

Season	Percentage of projected study area Common Murre population
Common Murre, projected fall (July-October) average population	70
Common Murre, projected winter (November-March) average population	41

*This represents 62% of the offshore component in the study area.

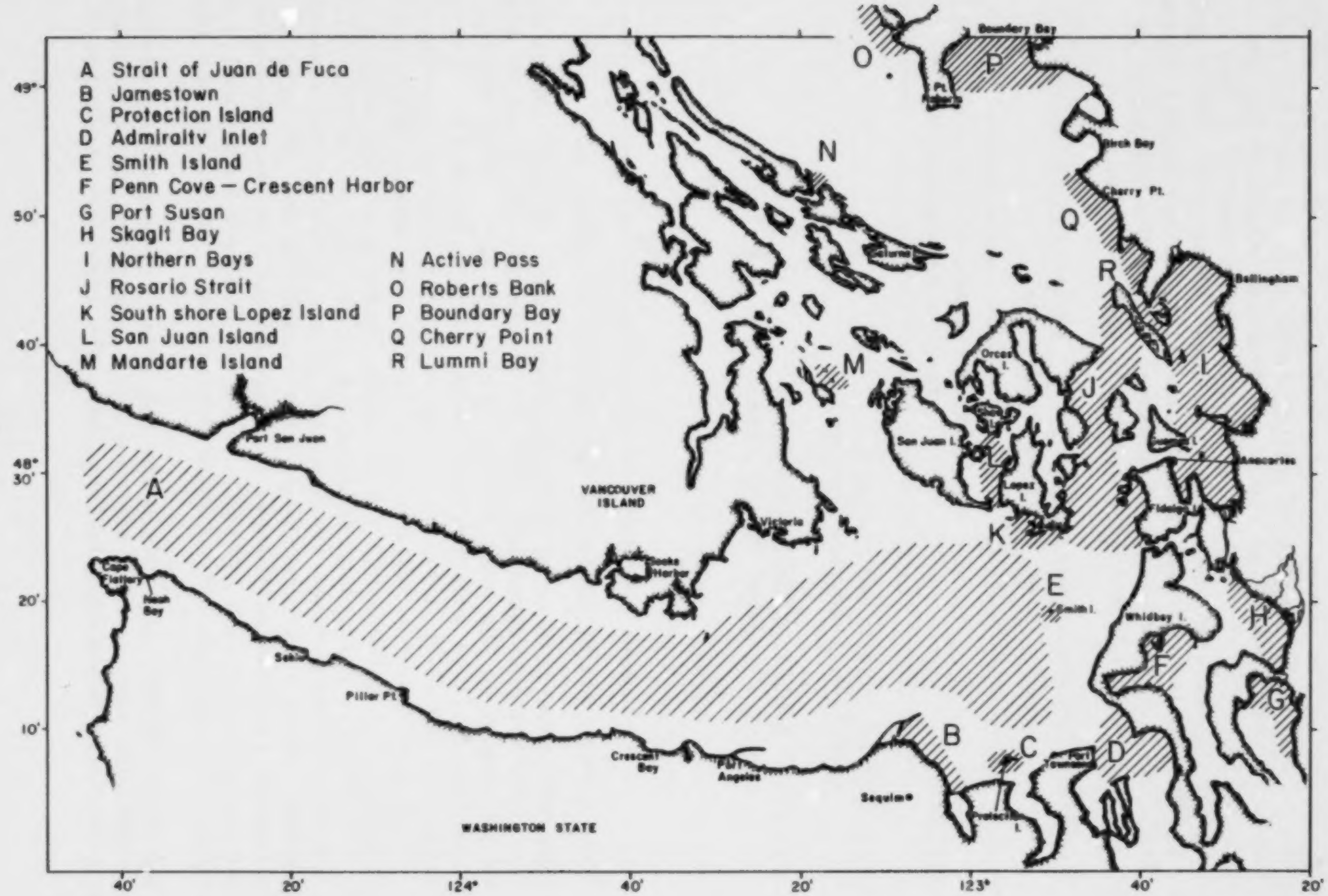

A Strait of Juan de Fuca
B Jamestown
C Protection Island
D Admiralty Inlet
E Smith Island
F Penn Cove — Crescent Harbor
G Port Susan
H Skagit Bay
I Northern Bays
J Rosario Strait
K South shore Lopez Island
L San Juan Island
M Mandarte Island
N Active Pass
O Roberts Bank
P Boundary Bay
Q Cherry Point
R Lummi Bay
VANCOUVER ISLAND
WASHINGTON STATE
Port San Juan
Victoria
Sooke Harbor
Cape Flattery
Neah Bay
Sekiu
Pillar Pt.
Crescent Bay
Port Angeles
Sequim
Port Townsend
Whidbey I.
Smith I.
Fidalgo I.
Anacortes
Bellingham
Cherry Pt.
Birch Bay
Boundary Bay
San Juan I.
Lopez I.
Orcas I.
49°
50'
40'
48° 30'
20'
10'
40'
20'
124°
40'
20'
123°
40'
20'

Figure 39. Map showing the areas of significant importance and vulnerability in the study area, 1978 and 1979 combined.

fish-net entanglement. Large numbers of some other species like phalaropes and Bonaparte's Gulls also forage along tidal convergences during migrations.

c. Jamestown. Protected from prevailing winds by Dungeness Spit, with productive shallow waters extending offshore, this is the single most important subregion for wintering waterfowl along the shoreline of the Strait of Juan de Fuca. Large numbers of diving ducks such as scoters, grebes, other shallow water divers, and large flocks of American Wigeon using the eelgrass beds, account for much of the high importance-vulnerability rating of the area between Dungeness and the mouth of Sequim Bay. Black Brant add significantly to the bird population and thus the vulnerability rating during spring migration. Table 23 gives percentage of seasonal use of the subregion by certain species. These percentages do not represent peak numbers.

Table 23. Jamestown (Subregion 0307): importance to several species (Area = < 1% of Study Area).

Season	Percentage of projected study area population
Black Brant, projected spring (April-May) average population	12
Waterfowl (ducks, geese) projected winter (November-March) total	9*
Great Blue Heron, summer (June) projected total	7

*With population at Dungeness Bay and Harbor added, 16%.

This subregion is a major foraging area. Many of the species mentioned in the previous section spend the night on the water. Some feed at night, while others remain in the area to feed during the day. Most species either feed on the bottom (like dabbling and diving ducks), or capture free-swimming prey (grebes). Shoreline areas are often used by flocks of roosting gulls and terns. While numbers of birds decreased during the summer, the subregion was used extensively as a foraging area by birds breeding on Protection Island and other colonies. Rhinoceros Auklets fed in the waters farther offshore, and in the late afternoon and evening some of the birds in the Jamestown area were observed flying toward the Protection Island colony. Pelagic Cormorants from Protection Island also foraged offshore here. The abandoned pier off Dungeness was the site of a breeding colony of Glaucous-winged Gulls and Pelagic Cormorants. Both species fed at least part of the time within the subregion.

The large numbers of birds using the area, the seasonal concentrations of highly vulnerable species like diving ducks, cormorants, grebes, brant and alcids, especially Rhinoceros Auklets, make the area very important to regional bird populations and highly vulnerable to oil spills and perturbations resulting from habitat alteration and disturbance.

d. Protection Island. Protection Island is the single most important seabird breeding colony in the study area and one of the major colonies in Washington. About 56% of all known breeding birds in the study area nest here (Table 5, Figures 8-21). About 22,000 pairs of six species currently nest here. Of this total, the Rhinoceros Auklet makes up about 17,000 pairs: this is about 95% of known pairs of these auklets nesting in Washington's inside waters. Furthermore, this one colony probably contains about 50% of all known nesting pairs in the contiguous United States. Nearly all the remainder are confined to Destruction Island, on the outer coast of Washington. From early spring through late summer, this species was present on Protection Island and foraged in waters in the Strait of Juan de Fuca-Inner, Admiralty Inlet, Rosario Strait, and San Juan Channel.

Almost all the Tufted Puffins east of Tatoosh Island nest on Protection Island. The Pelagic Cormorant colony here was the study area's single largest colony east of Tatoosh Island. These three species, along with the Rhinoceros Auklet, are highly vulnerable to oil. The largest Glaucous-winged Gull colony in the study area also adds to the importance of this island colony. In addition to potential impacts of oil spills in the immediate area of the island, displacement of the colony by recreational development or disruption of bird breeding cycles by human activities represent very serious threats to the Protection Island populations. Furthermore, the introduction of rats, cats, dogs, or other predators attendant to humans would have extremely serious effects in this colony, as have such introductions to many seabird colony islands (Jones and Byrd 1979). There are also direct relationships between Protection Island, which provides nesting and roosting habitat, and foraging areas in adjacent subregions. Protection Island's importance for nesting populations in the study area is summarized in Table 24.

Table 24. Protection Island (Subregion 0310): importance to nesting seabirds.

Nesting species	Percentage of study area nesting birds
Double-crested Cormorant	+
Pelagic Cormorant	15
Black Oystercatcher	10
Glaucous-winged Gull	31
Pigeon Guillemot	14
Rhinoceros Auklet	95
Tufted Puffin	24
Total All Species	56

e. Admiralty Inlet. The deep water area of strong tidal currents located generally between Point Wilson, Admiralty Head and Point Marrowstone is one of the most heavily used foraging areas for birds in Washington's inland waters. Large numbers of many species, particularly Rhinoceros Auklets in summer, are attracted to this area of extensive tidal currents. Many others pass through on daily movements between Puget Sound and Hood Canal and areas to the north, as well as during seasonal migrations.

The availability of the Edmonds-Port Townsend ferry in 1979 allowed more representative offshore sampling of this region than in 1978 when we observed consistent concentrations of birds feeding outside our census transects. Main concentrations of birds generally occurred at this northern constriction of Admiralty Inlet, and most birds foraged in the western-most one-third of this area. Rhinoceros Auklets, Common Murres, Ancient Murrelets, Marbled Murrelets, Pigeon Guillemots, Red-necked Grebes, Arctic Loons, Glaucous-winged Gulls, Heermann's Gulls, Bonaparte's Gulls, and other species foraged here in season. We estimated that in July 1979 as many as one-third of the Protection Island breeding Rhinoceros Auklet population passed Point Wilson as they traveled to feeding areas in tide-rips in Admiralty Inlet and adjacent areas to the south (Figure 25-26). This phenomenon, when added to similar feeding activities of other species, is responsible for one of the study area's highest importance-vulnerability ratings during the summer.

Nearshore habitats were seasonally important for several species. Grebes, Pelagic Cormorants, alcids, and other diving birds, Harlequin Ducks, scoters, and gulls used the kelp beds fringing the shore. Black Brant foraged along the shoreline, particularly at Point Hudson.

Many birds passed south through Admiralty Inlet daily, though their possible foraging areas in Puget Sound or Hood Canal are not presently known.

f. Smith Island. The Smith Island/Minor Island area is a nesting complex for five species of marine birds. It is the third of only three known Rhinoceros Auklet colony sites within the study area, and it also has an important Pelagic Cormorant colony (Tables 5 and 25). The foraging areas in the nearshore shallows were important for nesting species, for summering nonbreeders, and for migrants visiting the region. During the summer as many as 200 Harlequin Ducks used Smith Island as a resting place while they were temporarily flightless during the post-breeding moult.

g. Rocks and Islands on the South Shore of Lopez Island. Seven islands along the south shore of Lopez Island supported nesting colonies (Table 5). These, and adjacent foraging areas, formed a subregion of year-round importance to bird populations. Dispersed nesting colonies reduce dependence on just a few major sites and serve as a population "reservoir" for some species in the event of a catastrophic event occurring at a location such as Protection Island. Colville Island ranked as an important colony, even in comparison with Protection Island and Tatoosh Island, with the second largest gull colony within the study area, one of only six Double-crested Cormorant breeding colonies, one of a very few nest sites for Tufted Puffins, and a relatively important nesting location for Pigeon Guillemots and Pelagic Cormorants (Figures 10-21, Table 26).

Table 25. Smith Island (Subregion 0314): importance to nesting seabirds.

Nesting species	Percentage of study area nesting birds
Pelagic Cormorant	5
Black Oystercatcher	10
Glaucous-winged Gull	1
Pigeon Guillemot	2
Rhinoceros Auklet	3
Tufted Puffin	+
Total All Species	2

Table 26. Lopez Island (south shore, Subregion 0316): importance to nesting seabirds.

Nesting species	Percentage of study area nesting birds
Double-crested Cormorant	3
Pelagic Cormorant	7
Black Oystercatcher	19
Glaucous-winged Gull	11
Pigeon Guillemot	4
Tufted Puffin	2
Total All Species	5

Additionally, the subregion was one of the most important winter roosting areas in the entire study area. A major proportion of all cormorants wintering in the study area roosted on Whale and Mummy Rocks and on other islands and rocks off Lopez Island. Many of these birds foraged near the shore, and others like gulls, oystercatchers, and Harlequin Ducks fed along the intertidal zone. Some cormorants commuted daily between this subregion and shallow inland areas of Fidalgo, Padilla and Samish Bays, and others were observed to move into Skagit Bay to forage (Figure 27). We estimate that as many as 15-20% of the study area's cormorants may use this subregion for roosting.

h. Southern San Juan Channel. The area between Friday Harbor and the entrance of San Juan Channel south of Cattle Point includes very important foraging areas and several roosting areas. The areas of strong currents attract seasonally large numbers of convergence specialists like Arctic Loons, Brandt's Cormorants, Ancient Murrelets, and Common Murres in winter. The tidal fronts here were among the most important foraging areas used by Rhinoceros Auklets and Glaucous-winged Gulls in summer. During migrations, large numbers of Bonaparte's Gulls, Heermann's Gulls, Common Terns, and Northern Phalaropes forage here also. Flocks of birds which roosted on the rocks off the south shore of Lopez Island foraged in San Juan Channel.

i. Rosario Strait. This region contained a number of small islands which serve as important nesting colonies and roosting sites (Table 5, Figures 10-21 and 27). Nine separate colony sites included three of the study area's six Double-crested Cormorant nesting locations, and two Pelagic Cormorant nesting sites. Table 27 summarizes these features relative to the study area. Many of these birds, along with resident gulls and guillemots, foraged within the numerous, rich tidal convergences that occur in Rosario Strait itself. This situation was amplified in the winter when large numbers of cormorants roosted on the islands. In winter also, great numbers of murres entered the region daily to feed in the tidal convergence areas. These highly vulnerable murres and cormorants make up large populations in the subregion. These are also among the most important foraging subregions for Bonaparte's Gulls during their migrations. Large numbers of fish-eating loons, Heermann's Gulls, and other species of alcids also forage in Rosario Strait.

Table 27. Rosario Strait (Subregions 0901-0903): importance to nesting seabirds.

Nesting species	Percentage of study area nesting birds
Double-crested Cormorant	16
Pelagic Cormorant	3
Black Oystercatcher	13
Glaucous-winged Gull	9
Pigeon Guillemot	3
Total All Species	4

j. Padilla Bay. The three shallow embayments of Padilla, Samish, and Bellingham Bays were among the most important areas for wintering water birds in the entire study area. Padilla Bay itself may support about 10% of the birds wintering in the study area. The extensive shallow waters and tidal flats were used by many birds, including bottom-feeding diving ducks, dabbling ducks, grazing birds such as brant and wigeon, and shorebirds. Deeper parts of the bays were populated by other diving birds like loons, grebes, and cormorants. Large numbers of many species arrived in fall and stayed through the spring, making populations high for several months.

Many of the birds associated with the area spend their entire nonbreeding lives on the water. These include many diving ducks, loons, and grebes. Large flocks of many species were present in the area, where they fed on the surface, in the water column or on the bottom. Other species, like American Wigeon, roosted on the water at night and fed at the shoreline during the day or left the bay to feed in the uplands. Still other species fed on the exposed tidal flats and roosted on the water during high tide stages. Padilla Bay was the most important habitat in the study area for Black Brant. Maximum numbers of up to 50,000 stopped to feed at one time during spring migration, and the wintering flock here of about 7,000 was the largest in the study area. The importance of the extensive eelgrass (Zostera sp.) habitat is likely essential to the maintenance of the entire population of this species.

Double-crested Cormorants which roosted off the south shore of Lopez Island or on rocks in Rosario Strait foraged daily in Padilla Bay and adjacent Fidalgo Bay. Up to 300 Great Blue Herons fed in the shallows at low tide. This subregion represents one of the few consistently used locations where many nonbreeding diving ducks remain to summer in the study area. Large numbers of scaup, scoters, and smaller numbers of mergansers used the dredge-spoil islands adjacent to the Swinomish Slough at this critical season. The third largest Glaucous-winged Gull colony in the study area was also located here (Table 5). The south end of Padilla Bay was one of the study area's important shorebird habitats. Merlins and Peregrine Falcons wintered here where they preyed on shorebirds and small ducks. Bald Eagles nested in two or three locations around Padilla Bay, and winter numbers were high. Table 28 summarizes important features of Padilla Bay relative to the study area as a whole.

Table 28. Padilla Bay (Subregion 0504): seasonal importance to several species of seabirds.

Season	Percentage of projected study area populations
Black Brant, projected spring (April-May) average population	46
Waterfowl (ducks, geese), projected winter (November-March) average population	30
Great Blue Heron, projected summer (June) average population	21
Western Grebe, projected winter (November-March) average population	3

The Padilla Bay habitat and bird populations are subjected to many uncertainties and potential impacts. Vessel traffic through the Swinomish Slough is often heavy and is immediately adjacent to the gull colony and roosting area for diving ducks and Black Brant. There are also projects involving dredge-and-fill developments, and navigation channel dredging and spoil disposal projects planned for the sensitive Swinomish Slough area. The presence of two oil refineries and loading piers on March Point also represents potential perturbations of major scale. Recreation activities, such as boating centered at Bayview State Park, are sources of potentially major impacts particularly on Padilla Bay's very large wintering populations of Black Brant and American Wigeon.

k. Samish Bay. Samish Bay shares features with both Padilla Bay, to the south, and Bellingham Bay, to the north. Important concentrations of Black Brant and very large numbers of wintering waterfowl and diving birds gave nearshore Samish Bay species diversity, densities, and vulnerability ratings similar to Padilla Bay. The offshore component included large numbers of Red-throated Loons and Western Grebes which apparently interchange with Bellingham Bay.

The south end of Samish Bay is one of the most important shorebird habitats remaining in the eastern part of the study area. With Padilla Bay, it also supported the largest known Great Blue Heron population in the study area, and the numbers of wintering Bald Eagles along southern Bellingham, Samish and Padilla Bays were the largest in the mainland portion of the study area. The largest known wintering population of Peregrine Falcons in populated North America occurred in the Samish-Padilla Bays complex. Important features of Samish Bay are noted in Table 29.

Table 29. Samish Bay (Subregion 0505): seasonal importance to several species of seabirds.

Season	Percentage of projected study area populations
Black Brant, projected spring (April-May) average population	21
Waterfowl (ducks, geese), projected winter (November-March) average population	15
Great Blue Heron, projected summer (June) population	28
Western Grebe, projected winter (November-March) population	6

l. Bellingham Bay. This subregion, along with Port Angeles Bay, has been the most heavily-impacted by human activities in the study area. Dredge-and-fill of tidelands has been extensive along the north end of the bay. Disposal of large volumes of industrial effluents for many years has affected water quality. Log raft storage in the north bay has affected bottom sediments and water quality. Logging practices in the Nooksack River watershed have probably increased siltation rates and this, along with the diversion of the Nooksack River outfall from Lummi Bay into Bellingham Bay many years ago, has undoubtedly affected the extent and quality of marine bird habitats. While numbers of dabbling ducks, geese, swans, and shorebirds using the intertidal areas of the bay have unquestionably declined greatly since settlement began, the condition of some of the remaining nearshore areas along the southern shores and the offshore waters evidently remains productive.

Presently, seasonally large numbers of diving ducks and fish-eating species, particularly Western Grebes, attest to Bellingham Bay's importance. One of the largest known flocks of Western Grebes anywhere within that species' range wintered regularly in Bellingham Bay (see Appendix K-5). This flock is estimated to be 33% of all Western Grebes wintering in the study area. The subregion's high vulnerability ratings reflect this.

The Nooksack Delta is one of the most important estuaries in the study area. The study area's only flock of wintering Whistling Swans occurred here, and important numbers of Bald Eagles concentrate here as well.

m. Lummi Bay. This productive, shallow bay with extensive eelgrass beds supported very important wintering bird populations, particularly of diving and surface-feeding ducks, gulls, and shorebirds. Sizable flocks of migrating Black Brant stopped and foraged at Lummi Bay during the spring, and additional shorebird flocks were important migrants using the flats in spring and fall. There were also occasional herring spawn concentrations within the outer portion of Lummi Bay, off Sandy Point. The relatively high numbers of birds and the vulnerability of brant contributed to high importance-vulnerability ratings of Lummi Bay. Large numbers of Double-crested Cormorants and Great Blue Herons were also present in season. Bald Eagles and Peregrine Falcons wintered in the subregion, utilizing both adjacent diked farmlands and marine habitats for feeding. Features contributing to high importance-vulnerability ratings are given in Table 30.

n. Cherry Point. The open shorelines along the eastern perimeter of the Georgia Strait from Sandy Point to Point Whitehorn were important bird habitats during all seasons, featuring high numbers of fish-eating loons, grebes and alcids, along with diving ducks. Peak numbers occurred in late winter and early spring. Highest importance-vulnerability ratings resulted from the effects of herring spawning activities in March-May when huge concentrations of birds, particularly scoters and gulls, fed along the shoreline (see Table 31). This phenomenon varied somewhat in location each year, but largest numbers of associated birds were observed in 1978 and 1979 between Sandy Point and Point Whitehorn. The highest census density of birds observed anywhere in the study area--almost 13,000 per km^2--was within this subregion,

Table 30. Lummi Bay (Subregion 0601): seasonal importance to several species of seabirds.

Season	Percentage of projected study area populations
Black Brant, projected spring (April-May) average population	6
Waterfowl (ducks and geese) projected winter (November-March) average population	5
Great Blue Heron, projected summer (June) population	7

Table 31. Cherry Point (Subregion 0602): seasonal importance to several species of seabirds.

Season	Percentage of projected study area populations
Scoters, projected spring (April-May) average population	24
Arctic Loon, projected spring (April-May) average population	21*

*Includes flock immediately adjacent off Lummi Bay.

off Point Whitehorn, in April 1978. Effects of oil spills and other impacts on herring spawn and subsequently on bird populations, especially during the migration season, could be very extensive.

Some of the study's highest concentrations of Arctic Loons occurred in this subregion during the herring spawn season. Summer populations of several species, such as scoters and Harlequin Ducks, along this shoreline were also important. There are presently two oil refineries and an aluminum smelter located in this subregion and other sizable developments are proposed.

o. Boundary Bay, British Columbia. Boundary Bay is one of several very important subregions adjacent to our study area. These sites are biologically important units of the inland waters and impacts occurring within the MESA study area, depending on scale and duration, will also impact these areas. We regularly sampled a small section of shoreline along the east side of Point Roberts and one transect across the outer open waters of Boundary Bay between Point Roberts and Semiahmoo Spit. Results of this sampling effort are given (Appendix Tables D-42, E-42 and F-42). Based on these data, personal observations along the northern shoreline, and data from Vermeer and Levings (1977), we place Boundary Bay within the highest importance-vulnerability rankings in inland Canada-United States waters. The subregion was extremely important for loons, grebes, geese, dabbling and diving ducks, gulls, and shorebirds. Numbers of Great Blue Herons, Bald Eagles, and falcons occurred here also. Large numbers of Black Brant utilize Boundary Bay's extensive eelgrass beds, particularly during spring migration.

p. Roberts and Sturgeon Banks, British Columbia. The nearshore shallow area north from the Tsawwassen ferry terminal to Iona Island was among the most important wintering waterfowl areas in Canada and certainly in United States-Canada inland waters (Vermeer and Levings 1977). Very large numbers of dabbling ducks and shorebirds utilized this area in migration and winter. A large flock of Snow Geese (see Appendix K) wintered on the Westham Island foreshore, and a flock of Trumpeter and Whistling Swans wintered on Roberts Bank. Black Brant also gathered to forage in large numbers along southern Roberts Bank during the northward spring migration.

q. Active Pass, British Columbia. Strong tidal currents in this narrow passage concentrate prey items for very large numbers of marine birds and mammals. Peak densities here were probably greater during winter than in any other location of similar size in United States or Canadian inland waters (see Appendix Tables G-I, and also Edwards 1964, and Vermeer 1977). Three highly-vulnerable species--Arctic Loon, Brandt's Cormorant and Common Murre--were censused here in maximum numbers of up to 3,000 each in peak winter seasons. Table 32 illustrates some important features relative to the study area as a whole. Large flocks of Thayer's Gulls, Mew Gulls, Bonaparte's Gulls, and mergansers fed here also. Ten or more Bald Eagles and large groups of Northern or California sea lions were often present in winter. Killer whales frequently transit Active Pass.

r. Mandarte Island, British Columbia. Mandarte Island is the largest nesting colony in the British Columbia Gulf Islands area (Manuwal and

Table 32. Active Pass (Subregion 1301): seasonal importance to several species of seabirds.

Season	Percentage of projected study area populations
Arctic Loon, projected spring (April-May) average population	16
Brandt's Cormorant, projected spring (April-May) average population	62

Campbell 1979). Nesting populations of many species were comparable there to the highest in inland Washington waters, and the numbers of cormorants nesting on Mandarte are much greater than any other inland site in Washington or British Columbia (see Table 5). Its importance relative to nesting populations of the study area is shown in Table 33. Sidney Approach subregion was sampled incidentally to censuses in U.S. waters via the Anacortes-Sidney ferry. The marine areas near Mandarte Island, Sidney Island, along Sidney Spit and in Sidney Harbor had high species diversity and seasonally large numbers of vulnerable birds including Black Brant, Arctic Loon, Red-necked Grebes, Brandt's Cormorants, scoters, Oldsquaws, Common Murres, Pigeon Guillemots, and other species.

Table 33. Mandarte Island (Subregion 1303): importance to nesting seabirds.

Nesting species	Percentage of study area nesting seabirds
Double-crested Cormorant	80
Pelagic Cormorant	26
Black Oystercatcher	10
Glaucous-winged Gull	12
Pigeon Guillemot	4
Tufted Puffin	1
Total All Species	8

s. Skagit and Port Susan Bays. The MESA study area did not include areas east of Whidbey Island. Subsequent development proposals linking the study area with these areas make it necessary for us to draw attention to specific locations there.

The delta areas of the Skagit and Stilliguamish Rivers support very large populations of wintering waterfowl (Washington Department of Game unpub. data) and are among the most important habitats in Washington-British Columbia inland waters. This complex is comparable to Padilla Bay, Samish Bay and Boundary Bay, British Columbia in importance-vulnerability. A flock of about 300 Whistling Swans, up to 30,000 Snow Geese (see Appendix K),and large flocks of dabbling ducks wintered here, along wth many shorebirds and other species. These estuarine areas are quite vulnerable to catastrophic or chronic pollution or developments which would eliminate or degrade habitats.

t. Penn Cove and Crescent Harbor Area. There were high winter densities of diving ducks, particularly scoters, in these productive habitats near Oak Harbor. A large number of other diving birds, gulls and shorebirds were also present during migration and winter seasons. This is one of the few locations where sizable numbers of nonbreeding scoters spend the summer (see Appendix K). While disturbance, habitat loss, or degradation appears minimal at present, review of any future development plans should place high value on the biological importance of this area.

2. Highly Important Areas

There are several other areas or subregions which, while not scoring as high as those areas previously described as significantly important due to smaller size, are biologically very productive, heavily used by marine birds, vulnerable to the effects of oil, and highly important components of the study area. Many of these areas show species diversity and bird densities comparable to Significantly Important areas. Taken together, the sum of these smaller areas would easily rank as a major important area.

Many of these areas are the smaller embayments, estuaries, and other shallow water areas. The Significantly Important areas, plus this "second level" group of subregions represent the majority of highly productive marine bird habitats in the study area.

a. Crescent Bay to Ediz Hook Shoreline. Large numbers of gulls foraged along the shoreline and roosted on the beaches, particularly at the mouth of the Elwha River. Many alcids and grebes foraged along the nearshore area.

b. Dungeness Bay and Dungeness Spit. Large numbers of waterfowl used the protected Dungeness Bay and Harbor habitats. Black Brant fed over the eelgrass beds during migration; and large numbers of shorebirds, particularly Black-bellied Plovers, were found in the area. Large numbers of gulls roosted on Dungeness Spit between foraging flights over the Strait of Juan de Fuca.

c. Discovery Bay. Discovery Bay supported large numbers of scoters, Western Grebes, and Common Murres during the winter, and attracted additional birds during herring spawns.

d. Quimper Peninsula Shoreline. The nearshore area along the peninsula's northern shoreline was used by many diving birds. Large flocks of gulls occurred here, particularly in late summer-early fall when migrant gulls foraged over the Strait of Juan de Fuca.

e. Bellingham Channel. Flocks of Bonaparte's Gulls, Western Grebes, and Common Murres foraged in tidal convergences in the deep offshore areas of Bellingham Channel. The Viti Rocks colony supported a large number of Glaucous-winged Gulls and cormorants.

f. Birch Bay. Birch Bay is an important shallow bay supporting large numbers of wintering and migrant birds, including Black Brant, dabbling ducks, diving ducks, gulls, and shorebirds. As in a number of subregions, human recreation use of Birch Bay is extremely heavy, but occurs primarily during the season when few birds are using the area.

g. Birch Point to Semiahmoo Spit Shoreline. This shoreline supports important numbers of birds all year. Like the open shoreline to the south from Point Whitehorn to Sandy Point, very large numbers of scoters occurred there when herring spawned during late winter-early spring (see Table K-5). Herring spawning there is historically significant, though our samples in this subregion in 1978 and 1979 did not show scoter densities comparable to those at Cherry Point. Based on data from over a longer period of years, this subregion would almost certainly be rated as of Significant Importance.

h. Drayton Harbor. High species diversity, high densities, and impressive numbers of loons, diving ducks, dabbling ducks, Black Brant, shorebirds, and gulls characterize Drayton Harbor. Densities of Common Loons at Drayton Harbor, for example, were the highest within the study area. Drayton Harbor and the adjacent Semiahmoo Bay area are an important summering habitat for diving ducks.

i. Open Waters of Eastern Southern Georgia Strait. Though the offshore waters often had low densities of birds, the eastern section of Georgia Strait seasonally supports large numbers of birds, apparently often coincident with fish runs. During the spring herring spawn, large numbers of Arctic Loons, Common Murres, other alcids, diving birds, and Oldsquaws were found offshore.

j. Point Roberts--Tsawwassen Bay. The shoreline along southern Point Roberts and north to Tsawwassen Bay is an important wintering area for many diving ducks and other species of diving birds. Large flocks of loons, cormorants, alcids, gulls, and terns feed during fish runs in deep waters just offshore. Herring spawn attracts birds during the spring to this shoreline also.

k. Northern Haro Strait. Open water densities of Haro Strait were usually low, but large numbers of birds occurring along productive shorelines of Waldron Island and concentrations at several colonies and roosts resulted in a high overall rating.

l. Patos, Sucia, Matia Islands, and Rocks. Numbers of wintering birds foraging along shorelines and in convergence lines in the channels and offshore areas resulted in a high rating for this subregion. Some of the study area's highest nesting season densities of Pigeon Guillemots were observed here.

m. Lopez Sound. The protected waters of Lopez Sound, particularly the shallow southern area, provided winter habitat for the largest number of birds found in the interior of the San Juans. Wintering birds appeared relatively undisturbed in Lopez Sound. Species richness was high, with loons, grebes, cormorants, alcids, diving ducks, and gulls being well represented.

n. Race Rocks, British Columbia. These rocks were an important roosting site for cormorants along the Strait of Juan de Fuca. Approximately 23% of all known nesting Pelagic Cormorants of the region nested on these rocks, thus making it an important nesting site.

3. Other Important Areas

Small size and/or patchiness of bird flocks during censuses resulted in lower ratings of a number of obviously biologically rich subregions. These included the Neah Bay to Clallam Bay shoreline; Clallam Bay to Crescent Bay shoreline; Voice of America, Sequim Bay, Miller Peninsula shoreline; Whidbey Island shoreline; south shore of San Juan Island; Guemes Channel; Fidalgo Bay; Hales Passage; northern waters of the San Juans; Obstruction Pass; Mosquito Pass-Roche Harbor area; Griffin Bay and Fisherman Bay. Several of these areas, particularly the bays, rate very high in species "richness" of birds per km^2 or BOI rating per km^2.

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APPENDIX A

REGIONS AND SUBREGIONS, CODES, AND AREAS

TABLE A-1. BREAKDOWN OF REGIONS AND SUBREGIONS, THEIR CODES AND AREAS (KM^2) FOR NEARSHORE AND OFFSHORE COMPONENTS

		Region/ Subregion Code		Area (km^2)		
				Nearshore	Offshore	Total
Region	Swiftsure Bank	01--				
Subregion	Swiftsure Bank	0101			840.8	840.8
			Totals		840.8	840.8
Region	Strait of Juan de Fuca--Outer	02--				
Subregion	Strait of Juan de Fuca (outer)	0201			1,883.7	1,883.7
"	Vancouver Island	0202		51.5		51.5
"	Cape Flattery	0203		5.4		5.4
"	Neah Bay	0204		4.5		4.5
"	Neah Bay to Clallam Bay	0205		12.9		12.9
"	Clallam Bay	0206		3.2		3.2
"	Clallam Bay to Crescent Bay	0207		20.8		20.8
"	Crescent Bay	0208		1.1		1.1
"	Crescent Bay to Ediz Hook	0209		9.0		9.0
			Totals	108.4	1,883.7	1,992.1
Region	Strait of Juan de Fuca--Inner	03--				
Subregion	Strait of Juan de Fuca (Inner)	0301			1,630.8	1,630.8
"	Ediz Hook	0302		0.4		0.4
"	Port Angeles	0303		10.4		10.4
"	Voice of America	0304		24.0		24.0
"	Dungeness Spit	0305		4.0		4.0
"	Dungeness Bay/Harbor	0306		12.0		12.0
"	Jamestown	0307		21.4		21.4
"	Sequim Bay	0308		11.8	2.0	13.8
"	Miller Peninsula	0309		4.8		4.8

TABLE A-1 (continued).

		Region/ Subregion Code		Area (km^2)		
				Nearshore	Offshore	Total
Subregion	Protection Island	0310		3.1		3.1
"	Discovery Bay	0311		13.0	24.1	37.1
"	Quimper Peninsula	0312		10.7		10.7
"	Whidbey Island	0313		21.0		21.0
"	Smith Island	0314		0.3		0.3
"	Deception Pass	0315		5.6		5.6
"	Lopez Island (south shore)	0316		8.9		8.9
"	San Juan Island (south shore)	0317		3.5		3.5
"	Victoria, Vancouver Island	0318		6.9		
			Totals	161.8	1,656.9	1,818.7
Region	Admiralty Inlet	04--				
Subregion	Admiralty Inlet	0401		15.5	25.4	40.9
			Totals	15.5	25.4	40.9
Region	Anacortes to Hale Passage	05--				
Subregion	Bellingham Channel	0501		4.7	69.2	73.9
"	Guemes Channel	0502		10.2		10.2
"	Fidalgo Bay	0503		11.5		11.5
"	Padilla Bay	0504		55.0	25.0	80.0
"	Samish Bay	0505		29.0	37.0	66.0
"	Bellingham Bay	0506		36.0	122.0	158.0
"	Hale Passage	0507		16.1		16.1
			Totals	162.5	253.2	415.7

TABLE A-1 (continued).

		Region/ Subregion Code		Area (km^2)		
				Nearshore	Offshore	Total
Region	Georgia Strait--Eastern	06--				
Subregion	Lummi Bay	0601		17.0	8.0	25.0
"	Cherry Point	0602		14.1		14.1
"	Birch Bay	0603		9.0	10.0	19.0
"	Semiahmoo Spit	0604		9.5		9.5
"	Drayton Harbor	0605		12.8		12.8
"	Boundary Bay	0606		75.0	82.0	157.0
"	San Juan Islands--Northern Tier	0607		5.0	29.4	34.4
"	Georgia Strait	0608			288.3	288.3
			Totals	142.4	417.7	560.1
Region	Georgia Strait--Western	07--				
Subregion	Pt. Roberts	0701		16.3		16.3
"	Tsawwassen Bay	0702		6.1		6.1
"	Georgia Strait	0703			364.5	364.5
			Totals	22.4	364.5	386.9
Region	Haro Strait	08--				
Subregion	Northern Haro Strait	0801		9.6	329.1	338.7
"	Southern Haro Strait	0802		5.0	219.4	224.4
			Totals	14.6	548.5	563.1
Region	Rosario Strait	09--				
Subregion	Southern Rosario Strait	0901		10.8	112.4	123.2
"	Central Rosario Strait	0902		3.7	79.4	83.1
"	Northern Rosario Strait	0903		3.3	88.9	92.2
			Totals	17.8	280.7	298.5

TABLE A-1 (continued).

		Region/ Subregion Code		Area (km^2)		
				Nearshore	Offshore	Total
Region	San Juan Islands--Northern Waters	10--				
Subregion	President Channel	1001		3.2	100.4	103.6
"	Northern Areas	1002		2.0	48.0	50.0
			Totals	5.2	148.4	153.6
Region	San Juan Islands--Interior Channels and Passages	11--				
Subregion	Spelden Channel	1101		1.1	12.6	13.7
"	Northern San Juan Channel	1102		2.9	33.2	36.1
"	Southern San Juan Channel	1103		5.0	43.5	48.5
"	Wasp Pass	1104		2.5		2.5
"	Upright Channel	1105			8.8	8.8
"	Harney Channel	1106		2.2	30.7	32.9
"	Obstruction Pass	1107		2.5		2.5
"	Thatcher Pass	1108		0.9		0.9
			Totals	17.1	128.8	145.9
Region	San Juan Islands--Interior Bays	12--				
Subregion	Mosquito/Roche Complex	1201		6.0		6.0
"	Friday Harbor	1202		1.5		1.5
"	Griffin Bay	1203		7.5	7.5	15.0
"	Fisherman Bay	1205		1.9		1.9
"	Swifts/Shoal Bays	1206		4.6		4.6
"	Deer Harbor	1207		2.0		2.0
"	West Sound	1208		9.1		9.1

TABLE A-1 (continued).

		Region/ Subregion Code		Area (km^2)		
				Nearshore	Offshore	Total
Subregion	East Sound	1209		3.1	26.5	29.6
"	Lopez Sound	1210		23.9		23.9
			Totals	59.6	34.0	93.6
Region	Canadian Waters	13--				
Subregion	Active Pass	1301		10.5		10.5
"	Canadian Gulf Islands	1302			142.9	142.9
"	Sidney Approach	1303			117.5	117.5
			Totals	10.5	260.4	270.9
			Grand Totals	737.8	6,843.0	7,580.8

APPENDIX B

BIRD OIL INDEX VALUES AND METHODS OF DERIVATION

Derivation of Bird Oil Index Ratings

There are three components in the individual species Bird Oil Index (BOIs) value and each is equally weighted as given by

$$\mathrm{BOIs} = \left(\frac{1}{2.5} \sum_{i=1}^{5} X_i\right)\left(\frac{1}{2.5} \sum_{i=1}^{5} Y_i\right)\left(\frac{1}{2.0} \sum_{i=1}^{4} Z_i\right) \qquad (1)$$

or

$$\mathrm{BOIs} = X \cdot Y \cdot Z \qquad (2)$$

with respective components as above (1). The elements of the three components X, Y, Z are defined below.

X. Vulnerability of species as determined by habits of individual birds.

X_1. Roosting, night
Score 5: Nearly always roosts on water
" 3: Spends moderate time roosting on water
" 1: Spends minimal time roosting on water
" 0: Never roosts on water

X_2. Escape behavior
Score 5: Dives from danger
" 3: Swim for danger
" 1: Flies from danger

X_3. Flocking on water
Score 5: Forms large flocks
" 3: Variable
" 1: Forms small flocks
" 0: Does not flock (in water)

X_4. Nesting concentration
Score 5: Forms large colonies
" 3: Forms small colonies
" 1: Nests solitary

X_5. Feeding (foraging) specialization
Score 5: Highly specialized (narrow)
" 3: Moderately adaptable
" 1: Generalist

Y. Vulnerability of species as determined by total population characteristics.

Y_1. Population size
Score 5: Small population, limited numbers
" 3: Population of medium numbers
" 1: A large population

Y_2. Reproductive potential
Score 5: Low reproductive capacity
" 3: Moderate reproductive capacity
" 1: Highly prolific

Y_3. Breeding distribution
Score 5: Localized
" 3: Moderately widespread
" 1: Widespread

Y_4. Winter distribution
Score 5: Concentrated
" 3: Moderately scattered (concentrated)
" 1: Widely scattered

Y_5. Seasonal exposure in marine habitats
Score 5: All year
" 3: Moderate time on marine water
" 1: Minimal time on marine waters

Z. Significance of our area to whole population.

Z_1 = Spring
Z_2 = Summer
Z_3 = Fall
Z_4 = Winter

Score 5: Large proportion of population utilizes area
" 3: Moderate " " " " "
" 1: Relatively small proportion of population utilizes area
" 0: Area not utilized

TABLE B-1. BIRD OIL INDEX VALUES FOR SPECIES OCCURRING IN THE STUDY AREA, MARINE WATERS OF THE STATE OF WASHINGTON

Species	Vulnerability of Species as Determined by				Significance of our area to the total species populations		BOI*
	habits of individual		total population characteristics				
	$X_1X_2X_3X_4X_5$	$\Sigma X_i/2.5$	$Y_1Y_2Y_3Y_4Y_5$	$\Sigma Y_i/2.5$	$Z_1Z_2Z_3Z_4$	$\Sigma Z_i/2.0$	
LOONS							
Common Loon	55115	6.8	15123	4.4	3133	5.0	149.6
Yellow-billed Loon	55115	6.8	55353	8.4	0001	0.5	28.6
Arctic Loon	55415	8.0	35123	5.6	3033	4.5	201.6
Red-throated Loon	55315	7.6	15335	6.8	3033	4.5	232.6
Large Loon[1]	55115	6.8	15223	5.2	3133	5.0	176.8
Small Loon[2]	55315	7.6	25234	6.4	3033	4.5	218.9
Loon (species)	55115	6.8	15223	5.2	3133	5.0	176.8
GREBES							
Red-necked Grebe	55215	7.2	13143	4.8	3033	4.5	155.5
Horned Grebe	55315	7.6	13143	4.8	3033	4.5	164.2
Eared Grebe	55315	7.6	13122	3.6	0001	0.5	13.7
Western Grebe	55515	8.4	13335	6.0	3135	6.0	302.4
Pied-billed Grebe	55115	6.8	13111	2.8	0001	0.5	9.5
Large Grebe[3]	55315	7.6	13334	5.6	3135	6.0	255.4
Small Grebe[4]	55315	7.6	13143	4.8	3033	4.5	164.2
Grebe (species)	55315	7.6	13133	4.4	3133	5.0	167.2
ALBATROSS							
Black-footed Albatross	53154	7.2	35515	7.6	111	2.0	109.4
Albatross (species)	53154	7.2	35515	7.6	111	2.0	109.4

TABLE B-1 (continued).

Species	Vulnerability of Species as Determined by				Significance of our area to the total species populations		BOI[a]
	habits of individual		total population characteristics				
SHEARWATERS AND FULMARS							
Northern Fulmar	53353	7.6	15115	5.2	1111	2.0	79.0
Pink-footed Shearwater	53353	7.6	15315	6.0	1110	1.5	68.4
Buller's Shearwater	53353	7.6	35545	8.8	0010	0.5	33.4
Sooty Shearwater	53553	8.4	15115	5.2	1110	1.5	65.5
Light-bellied Shearwater[5]	53353	7.6	15315	6.0	1110	1.5	68.4
Shearwater (species)	53553	8.4	15115	5.2	1110	1.5	65.5
STORM-PETRELS							
Fork-tailed Storm-Petrel	53355	8.4	15335	6.8	1110	1.5	85.7
Storm-Petrel (species)	53355	8.4	15335	6.8	1110	1.5	85.7
PELICANS							
Brown Pelican	53253	7.2	34435	7.6	0010	0.5	27.4
CORMORANTS							
Double-crested Cormorant	13242	4.8	33123	4.8	3333	6.0	138.2
Brandt's Cormorant	13453	6.4	43445	8.0	1034	4.0	204.8
Pelagic Cormorant	13343	5.6	33335	6.8	3333	6.0	228.5
Cormorant sp.	13343	5.6	33335	6.8	3333	6.0	228.5
Large Cormorant	13343	5.6	33334	6.4	3333	6.0	215.0
Small Cormorant	13343	5.6	33335	6.8	3333	6.0	228.5
HERONS AND BITTERNS							
Great Blue Heron	11131	2.8	33111	3.6	3331	5.0	50.4
Green Heron	11113	2.8	23111	3.2	2220	3.0	26.9
American Bittern	11113	2.8	23111	3.2	1001	1.0	9.0

TABLE B-1 (continued).

Species	Vulnerability of Species as Determined by				Significance of our area to the total species populations		BOI*
	habits of individual		total population characteristics				
SWANS, GEESE, AND DUCKS							
Whistling Swan	51413	5.6	33343	6.4	1013	2.5	89.6
Trumpeter Swan	51413	5.6	53541	7.2	1011	1.5	60.5
Swan sp.	51413	5.6	33343	6.4	1011	1.5	53.8
Canada Goose	31311	8.6	33111	3.6	1111	2.0	25.9
American Brant	53433	7.2	33335	6.8	0010	0.5	24.5
Black Brant	53433	7.2	43335	7.2	5044	6.5	337.0
White-fronted Goose	11311	2.8	33331	5.2	2020	2.0	29.1
Small Goose	33331	5.2	33331	5.2	5044	6.5	175.8
Goose sp.	33331	5.2	33335	6.8	3033	4.5	159.1
Snow Goose	11441	4.4	33411	4.8	3035	5.5	116.2
Mallard	33311	4.4	31111	2.8	1112	2.5	30.8
Gadwall	33311	4.4	31311	3.6	1011	1.5	23.8
Northern Pintail	33411	4.8	31111	2.8	3033	4.5	60.5
American Green-winged Teal	33311	4.4	31111	2.8	1013	2.5	30.8
Blue-winged Teal	33211	4.0	31111	2.8	0110	1.0	11.2
European Wigeon	33211	4.0	31511	4.4	1013	2.5	44.0
American Wigeon	33411	4.8	31111	2.8	3033	4.5	60.5
Northern Shoveler	33311	4.4	31111	2.8	3033	4.5	55.4
Dabbling Duck	33311	4.4	31111	2.8	3033	4.5	55.4
Teal sp.	33311	4.4	31111	2.8	1013	2.5	30.8
Canvasback	35413	6.4	53113	5.2	1012	2.0	66.6
Greater Scaup	35413	6.4	13115	4.4	3134	5.5	154.9
Lesser Scaup	35413	6.4	13113	3.6	1011	1.5	34.6
Scaup sp.	35413	6.4	13115	4.4	3134	5.5	154.9
Anatinine Ducks	35413	6.4	13111	2.8	3134	5.5	98.6
Common Goldeneye	55313	6.8	13113	3.6	3033	4.5	110.2

TABLE B-1 (continued).

Species	Vulnerability of Species as Determined by				Significance of our area to the total species populations		BOI*
	habits of individual		total population characteristics				
Barrow's Goldeneye	55413	7.2	13313	4.4	3035	5.5	174.2
Goldeneye sp.	55313	6.8	13113	3.6	3033	4.5	110.2
Bufflehead	55313	6.8	13113	3.6	3033	4.5	110.2
Oldsquaw	55313	6.8	13115	4.4	3033	4.5	134.6
Harlequin Duck	13313	4.4	13335	6.0	3434	7.0	184.8
King Eider	55513	7.6	13335	6.0	0001	0.5	22.8
White-winged Scoter	55513	7.6	13314	4.8	3234	6.0	218.9
Surf Scoter	55513	7.6	13315	5.2	4234	6.5	256.9
Black Scoter	55513	7.6	13315	5.2	3034	5.0	197.6
Scoter sp.	55513	7.6	13315	5.2	3234	6.0	237.1
Ruddy Duck	55513	7.6	11113	2.8	1013	2.5	53.2
Diving Duck	55413	7.2	13315	5.2	3134	5.5	205.9
Hooded Merganser	33113	4.4	33111	3.6	3034	5.0	79.2
Common Merganser	35413	6.4	13113	3.6	3034	5.0	115.2
Red-breasted Merganser	35313	6.0	13115	4.4	3034	5.0	132.0
Merganser sp.	35313	6.0	13115	4.4	3034	5.0	132.0
Duck sp.	33313	5.2	13113	3.6	3033	4.5	84.2
HAWKS AND EAGLES							
Golden Eagle	01011	1.2	55111	5.2	0001	0.5	3.1
Bald Eagle	01012	1.6	55121	5.6	4444	8.0	71.7
Eagle sp.	01012	1.6	55121	5.6	4444	8.0	71.7
OSPREYS							
Osprey	01014	2.4	55111	5.2	1110	1.5	18.7

TABLE B-1 (continued).

Species	Vulnerability of Species as Determined by habits of individual		Vulnerability of Species as Determined by total population characteristics		Significance of our area to the total species populations		BOI*
FALCONS							
Peregrine Falcon	01013	2.0	55111	5.2	4045	6.5	67.6
Merlin	01013	2.0	55111	5.2	3034	5.0	52.0
Falcon sp.	01013	2.0	55111	5.2	3034	5.0	52.0
RAILS							
American Coot	31211	3.2	11111	2.0	3033	4.5	28.8
OYSTERCATCHERS							
Black Oystercatcher	11125	4.0	35555	9.2	3333	6.0	220.8
PLOVERS							
Charadriidae	11113	2.8	33123	4.8	2132	4.0	53.8
Semipalmated Plover	11112	2.4	13111	2.8	3030	3.0	20.2
Killdeer	11111	2.0	13111	2.8	3332	5.5	30.8
American Golden Plover	11113	2.8	33113	4.4	1010	1.0	12.3
Black-bellied Plover	11113	2.8	33115	5.2	3031	3.5	51.0
Pluvialis sp.	11113	2.8	33115	5.2	3031	3.5	51.0
Plover sp.	11113	2.8	33113	4.4	3031	3.5	43.1
SANDPIPERS AND OTHER SHOREBIRDS							
Scolopacidae sp.	11112	2.4	33213	4.8	3032	4.0	46.1
Ruddy Turnstone	11113	2.8	33135	6.0	2020	2.0	33.6
Black Turnstone	11113	2.8	33535	7.6	4043	5.5	117.0
Turnstone sp.	11113	2.8	33535	7.6	4043	5.5	117.0
Common Snipe	11111	2.0	13111	2.8	1011	1.5	8.4
Long-billed Curlew	11112	2.4	33311	4.4	1010	1.0	10.6
Whimbrel	11113	2.8	33113	4.4	3130	3.5	43.1

TABLE B-1 (continued).

Species	Vulnerability of Species as Determined by				Significance of our area to the total species populations		BOI*
	habits of individual		total population characteristics				
Curlew sp.	11113	2.8	33313	5.2	3130	3.5	51.0
Spotted Sandpiper	11111	2.0	13111	2.8	1110	1.5	8.4
Greater Yellowlegs	11111	2.0	33111	3.6	3030	3.0	21.6
Lesser Yellowlegs	11111	2.0	33111	3.6	3030	3.0	21.6
Yellowlegs sp.	11111	2.0	33111	3.6	3030	3.0	21.6
Wandering Tattler	11113	2.8	53515	7.6	1020	1.5	31.9
Willet	11112	2.4	33313	5.2	1110	1.5	18.7
Surfbird	11113	2.8	33555	8.4	3033	4.5	105.8
Red Knot	11112	2.4	33115	5.2	0010	0.5	6.2
Rock Sandpiper	11113	2.8	33535	7.6	0001	0.5	10.6
Pectoral Sandpiper	11113	2.8	33131	4.4	1030	2.0	24.6
Baird's Sandpiper	11112	2.4	33131	4.4	1030	2.0	21.1
Least Sandpiper	11112	2.4	13133	4.4	3131	4.0	42.2
Dunlin	11112	2.4	13115	4.4	3034	5.0	52.8
Western Sandpiper	11112	2.4	13535	6.8	3031	3.5	57.1
Sanderling	11113	2.8	33315	6.0	2022	3.0	50.4
Calidris Sandpiper	11113	2.8	33313	5.2	3033	4.5	65.5
Peep	11112	2.4	13114	4.0	3031	3.5	33.6
Short-billed Dowitcher	11113	2.8	33333	6.0	3030	3.0	50.4
Long-billed Dowitcher	11113	2.8	33533	6.8	3030	3.0	57.1
Dowitcher sp.	11113	2.8	33433	6.4	3030	3.0	53.8
Marbled Godwit	11113	2.8	33313	5.2	0010	0.5	7.3
PHALAROPES							
Red Phalarope	51114	4.8	13315	5.2	0010	0.5	12.5
Northern Phalarope	51514	6.4	13315	5.2	1030	2.0	66.6
Phalarope sp.	51514	6.4	13315	5.2	1030	2.0	66.6

TABLE B-1 (continued).

Species	Vulnerability of Species as Determined by				Significance of our area to the total species populations		BOI*
	habits of individual		total population characteristics				
JAEGERS AND SKUAS							
Pomarine Jaeger	31213	4.0	13115	4.4	0010	0.5	8.8
Parasitic Jaeger	31213	4.0	13115	4.4	2020	1.0	17.6
Long-tailed Jaeger	31213	4.0	13113	3.6	0010	0.5	7.2
Jaeger sp.	31213	4.0	13115	4.4	2020	2.0	35.2
Large Jaeger	31213	4.0	13115	4.4	2020	2.0	35.2
Small Jaeger	31213	4.0	13113	3.6	2020	2.0	28.8
Skua	31113	3.6	13115	4.4	0010	0.5	7.9
GULLS AND TERNS							
Glaucous Gull	31331	4.4	13135	5.2	0001	0.5	11.4
Glaucous-winged Gull	31351	5.2	13235	5.6	3334	6.5	189.3
Western Gull	31351	5.2	23335	6.4	1111	2.0	66.6
Western x Glaucous-w. Gull	31351	5.2	13335	6.0	3334	6.5	202.8
Herring Gull	31341	4.8	13113	3.6	1012	2.0	34.6
Thayer's Gull	31351	5.2	33353	6.8	3034	5.0	176.8
California Gull	31351	5.2	13323	4.8	2041	3.5	87.4
Dark Immature Gull	31351	5.2	13333	5.2	2032	3.5	94.6
Ring-billed Gull	31351	5.2	13123	4.0	1010	1.0	20.8
Mew Gull	31331	4.4	13123	4.0	3033	4.5	79.2
Dark Wing-tipped Gull	31351	5.2	13233	4.8	3033	4.5	112.3
Franklin's Gull	31352	5.6	23313	4.8	0010	0.5	13.4
Bonaparte's Gull	31512	4.8	13123	4.0	4141	5.0	96.0
Little Gull	31312	4.0	53553	8.4	0010	0.5	16.8
Heerman's Gull	31351	5.2	33525	7.2	0240	3.0	112.3
Black-legged Kittiwake	31353	6.0	13115	4.4	1011	1.5	39.6
Sabine's Gull	31333	5.2	13335	6.0	1010	1.0	31.2
Small Gull	31322	4.4	13335	6.0	3131	4.0	105.6

TABLE B-1 (continued).

Species	Vulnerability of Species as Determined by				Significance of our area to the total species populations		BOI*
	habits of individual		total population characteristics				
Common Tern	11343	4.8	13113	3.6	3030	3.0	51.8
Arctic Tern	11343	4.8	13115	4.4	1010	1.0	21.1
Small Tern	11343	4.8	13113	3.6	3030	3.0	51.8
Caspian Tern	11353	5.2	13313	4.4	0110	1.0	22.9
Tern sp.	11343	4.8	13113	3.6	3030	3.0	51.8
Laridae sp.	31341	4.8	13333	5.2	3333	6.0	149.8
Gull sp.	31341	4.8	13333	5.2	3333	6.0	149.8
AUKS, MURRES, AND PUFFINS							
Common Murre	55554	9.6	15125	5.6	3144	6.0	322.6
Thick-billed Murre	55554	9.6	15125	5.6	0010	0.5	26.9
Marbled Murrelet	55415	8.0	25445	8.0	4444	8.5	544.0
Ancient Murrelet	55455	9.6	13445	6.8	2024	4.0	261.1
Xantus Murrelet	55245	8.4	33545	8.0	0010	0.5	33.6
Cassin's Auklet	55555	10.0	15445	7.6	1110	1.5	114.0
Rhinoceros Auklet	55555	10.0	15435	7.2	4541	7.0	504.0
Tufted Puffin	55355	9.2	15315	6.0	1110	1.5	82.8
Large Alcid	55355	9.2	15335	6.8	3331	5.0	312.8
Small Alcid	55555	10.0	15445	7.6	4444	8.0	608.0
Murrelet sp.	55454	9.2	25445	8.0	4444	8.0	588.8
Alcid sp.	55455	9.6	14335	6.4	3333	6.0	368.6

*Bird Oil Index (BOI). B.O.I. = $\left(\frac{\Sigma X_i}{2.5}\right)\left(\frac{\Sigma Y_i}{2.5}\right)\left(\frac{\Sigma Z_i}{2.0}\right)$ See Appendix B, equation 1.

[1] Arctic/Red-throated Loon

[2] Common/Yellow-billed Loon

[3] Red-necked/Western Grebe

[4] Horned/Eared Grebe

[5] Pink-footed/Buller's Shearwater

APPENDIX C

SEASONAL OCCURRENCES AND TAXONOMIC LIST OF BIRD SPECIES OBSERVED IN STUDY AREA, 1978 AND 1979

TABLE C-1. REGIONAL OCCURRENCES OF BIRD SPECIES IN SPRING 1978 AND 1979

Species	Region 1*	2	3	4	5	6	7	8	9	10	11	12	13
LOONS													
Common Loon		x	x	x	x	x	x	x	x		x	x	x
Yellow-billed Loon			x		x								
Arctic Loon		x	x	x	x	x	x	x	x	x	x	x	x
Red-throated Loon		x	x	x	x	x	x		x		x	x	x
GREBES													
Red-necked Grebe		x	x	x	x	x	x	x	x	x	x	x	x
Horned Grebe		x	x	x	x	x	x	x	x	x	x	x	x
Eared Grebe			x			x	x					x	
Western Grebe		x	x	x	x	x	x	x	x	x	x	x	x
Pied-billed Grebe									x				
CORMORANTS													
Double-crested Cormorant		x	x	x	x	x	x	x	x		x	x	x
Brandt's Cormorant		x	x	x	x	x	x	x	x		x	x	x
Pelagic Cormorant		x	x	x	x	x	x	x	x	x	x	x	x
HERONS AND BITTERNS													
Great Blue Heron		x	x		x	x	x	x	x	x	x	x	x
Green Heron					x								
SWANS, GEESE, AND DUCKS													
Canada Goose			x		x	x			x				
Black Brant		x	x	x	x	x	x	x	x		x		x
Mallard		x	x	x	x	x					x		
Gadwall						x							
Northern Pintail			x		x	x							

TABLE C-1 (continued).

Species	Region 1*	2	3	4	5	6	7	8	9	10	11	12	13
American Green-winged Teal		x	x		x	x						x	
European Wigeon			x										
American Wigeon		x	x		x	x							
Northern Shoveler			x		x	x						x	
Canvasback					x	x							
Greater Scaup		x	x	x	x	x	x		x		x	x	x
Lesser Scaup			x		x								
Common Goldeneye		x	x	x	x	x	x	x	x	x	x	x	x
Barrow's Goldeneye		x	x		x	x						x	
Bufflehead		x	x	x	x	x	x	x	x	x	x	x	x
Oldsquaw		x	x	x	x	x	x	x	x	x	x	x	x
Harlequin Duck		x	x	x	x	x	x	x	x		x	x	x
White-winged Scoter		x	x	x	x	x	x	x	x	x	x	x	x
Surf Scoter		x	x	x	x	x	x	x	x	x	x	x	x
Black Scoter		x	x		x	x	x				x		
Ruddy Duck		x	x		x	x						x	
Hooded Merganser			x		x								
Common Merganser		x	x		x	x							x
Red-breasted Merganser		x	x	x	x	x	x	x	x	x	x	x	x
HAWKS AND EAGLES													
Bald Eagle		x	x		x	x		x	x	x	x	x	x
OSPREYS													
Osprey		x	x						x		x	x	
RAILS													
American Coot		x	x		x	x							

TABLE C-1 (continued).

Species	Region												
	1*	2	3	4	5	6	7	8	9	10	11	12	13
OYSTERCATCHERS													
Black Oystercatcher		x	x		x	x			x		x		
PLOVERS													
Semipalmated Plover			x			x							
Killdeer		x	x	x	x	x	x					x	
Black-bellied Plover		x	x		x	x							
SANDPIPERS AND OTHER SHOREBIRDS													
Ruddy Turnstone		x	x						x				
Black Turnstone		x	x		x	x	x		x		x		
Common Snipe						x							
Long-billed Curlew		x											
Whimbrel		x	x		x	x						x	
Spotted Sandpiper		x	x		x	x							
Greater Yellowlegs		x	x		x	x							
Lesser Yellowlegs			x			x							
Wandering Tattler		x	x										
Willet		x											
Surfbird		x			x	x							
Rock Sandpiper		x	x		x				x				
Least Sandpiper		x	x										
Dunlin		x	x		x	x							
Western Sandpiper		x	x		x	x	x					x	
Sanderling		x	x			x	x						
Short-billed Dowitcher		x	x		x	x						x	
Long-billed Dowitcher		x	x										

TABLE C-1 (continued).

Species	Region 1*	2	3	4	5	6	7	8	9	10	11	12	13
PHALAROPES													
Northern Phalarope		x							x				
JAEGERS AND SKUAS													
Parasitic Jaeger					x	x							
GULLS AND TERNS													
Glaucous Gull						x							
Glaucous-winged Gull		x	x	x	x	x	x	x	x	x	x	x	x
Western Gull		x	x										
Herring Gull		x	x			x	x	x	x	x	x		x
Thayer's Gull		x	x		x	x	x						x
California Gull			x	x	x	x	x		x		x		x
Ring-billed Gull			x		x	x							
Mew Gull		x	x	x	x	x	x	x	x	x	x	x	x
Bonaparte's Gull		x	x	x	x	x	x	x	x	x	x	x	x
Heermann's Gull		x											
Black-legged Kittiwake		x											
Common Tern			x		x	x	x	x	x				
Caspian Tern		x											
ALCIDS													
Common Murre		x	x	x	x	x	x	x	x	x	x	x	x
Pigeon Guillemot		x	x	x	x	x	x	x	x	x	x	x	x
Marbled Murrelet		x	x	x	x	x	x	x	x	x	x	x	x
Cassin's Auklet			x				x						
Rhinoceros Auklet		x	x	x	x	x		x	x		x	x	x
Tufted Puffin		x	x	x									

Note: *Not censused during period.

TABLE C-2. REGIONAL OCCURRENCES OF BIRD SPECIES IN SUMMER 1978 AND 1979

Species	Region 1	2	3	4	5	6	7	8	9	10	11	12	13
LOONS													
Common Loon		x	x		x	x	x	x	x			x	x
Arctic Loon		x	x		x	x	x		x		x	x	
Red-throated Loon			x		x	x							
GREBES													
Red-necked Grebe					x	x							
Horned Grebe		x	x			x							
Western Grebe			x		x	x	x	x					
SHEARWATERS													
Northern Fulmar	x												
Pink-footed Shearwater	x												
Sooty Shearwater	x		x										
STORM-PETRELS													
Fork-tailed Storm-Petrel	x		x										
CORMORANTS													
Double-crested Cormorant		x	x		x	x	x	x	x	x	x	x	x
Brandt's Cormorant		x	x		x			x	x		x		x
Pelagic Cormorant		x	x	x	x	x	x	x	x	x	x	x	x
HERONS AND BITTERNS													
Great Blue Heron		x	x		x	x	x		x		x	x	x

TABLE C-2 (continued).

Species	Region 1	2	3	4	5	6	7	8	9	10	11	12	13
SWANS, GEESE, AND DUCKS													
Canada Goose			x										
Black Brant			x			x							
Snow Goose			x										
Mallard			x		x	x							
Gadwall					x								
Northern Pintail			x		x	x							
American Wigeon			x										
Greater Scaup		x	x		x	x	x						
Common Goldeneye					x	x							
Barrow's Goldeneye						x							
Bufflehead			x			x						x	
Oldsquaw			x		x	x							
Harlequin Duck		x	x	x	x	x	x	x	x			x	x
White-winged Scoter		x	x	x	x	x	x			x		x	x
Surf Scoter		x	x	x	x	x	x	x	x		x	x	x
Black Scoter			x			x							
Ruddy Duck						x							
Hooded Merganser											x		
Common Merganser		x			x	x							
Red-breasted Merganser			x		x	x							
HAWKS AND EAGLES													
Bald Eagle		x	x		x	x	x	x	x		x	x	x
OSPREYS													
Osprey		x											

TABLE C-2 (continued).

Species	Region 1	2	3	4	5	6	7	8	9	10	11	12	13
RAILS													
American Coot						x							
OYSTERCATCHERS													
Black Oystercatcher		x	x				x		x		x		x
PLOVERS													
Semipalmated Plover			x		x	x							
Killdeer		x	x		x	x	x					x	
Black-bellied Plover			x		x	x							
SANDPIPERS AND OTHER SHOREBIRDS													
Ruddy Turnstone			x										
Black Turnstone			x										
Common Snipe			x										
Whimbrel		x	x			x							
Spotted Sandpiper		x	x		x	x							
Greater Yellowlegs		x	x		x	x							
Wandering Tattler			x										
Least Sandpiper		x			x	x							
Dunlin			x										
Western Sandpiper		x	x		x	x							
Sanderling			x										
Short-billed Dowitcher		x	x	x	x								
JAEGERS AND SKUAS													
Parasitic Jaeger						x							

TABLE C-2 (continued).

Species	Region 1	2	3	4	5	6	7	8	9	10	11	12	13
GULLS AND TERNS													
Glaucous-winged Gull	x	x	x	x	x	x	x	x	x	x	x	x	x
Western Gull	x	x	x				x						
Herring Gull		x	x	x			x						
Thayer's Gull			x										
California Gull	x	x	x		x	x	x	x	x	x	x		
Ring-billed Gull		x	x	x	x	x						x	
Mew Gull		x	x		x	x			x		x		
Bonaparte's Gull		x	x	x	x	x	x	x	x	x	x		
Heermann's Gull		x	x	x		x					x	x	
Black-legged Kittiwake									x	x			
Common Tern					x	x							
Caspian Tern		x	x	x	x	x							
ALCIDS													
Common Murre	x	x	x	x	x	x	x	x	x		x	x	x
Pigeon Guillemot		x	x	x	x	x	x	x	x	x	x	x	x
Marbled Murrelet		x	x	x	x	x	x	x	x	x	x	x	x
Cassin's Auklet	x												x
Rhinoceros Auklet	x	x	x	x	x		x	x	x	x	x	x	x
Tufted Puffin	x	x	x					x					x

TABLE C-3. REGIONAL OCCURRENCES OF BIRD SPECIES IN FALL 1978 AND 1979

Species	Region 1	2	3	4	5	6	7	8	9	10	11	12	13
LOONS													
Common Loon	x	x	x	x	x	x	x	x	x	x	x	x	x
Yellow-billed Loon													x
Arctic Loon	x	x	x	x	x	x	x	x	x	x	x	x	x
Red-throated Loon	x	x	x		x	x	x	x	x		x	x	x
GREBES													
Red-necked Grebe	x	x	x	x	x	x	x	x	x		x	x	x
Horned Grebe	x	x	x	x	x	x	x	x	x	x	x	x	x
Eared Grebe			x		x	x							
Western Grebe	x	x	x	x	x	x	x	x	x	x	x	x	x
Pied-billed Grebe			x		x	x							
ALBATROSS													
Black-footed Albatross	x												
SHEARWATERS													
Northern Fulmar	x		x										
Pink-footed Shearwater	x												
Buller's Shearwater	x												
Sooty Shearwater	x	x	x										
STORM-PETRELS													
Fork-tailed Storm-Petrel	x	x	x										
CORMORANTS													
Double-crested Cormorant		x	x	x	x	x	x	x	x	x	x	x	x
Brandt's Cormorant		x	x	x	x	x	x	x	x		x	x	x
Pelagic Cormorant	x	x	x	x	x	x	x	x	x	x	x	x	x

TABLE C-3 (continued).

Species	Region 1	2	3	4	5	6	7	8	9	10	11	12	13
HERONS AND BITTERNS													
Great Blue Heron	x	x	x	x	x	x	x	x	x	x	x	x	x
Green Heron					x								
American Bittern					x								
SWANS, GEESE, AND DUCKS													
Canada Goose			x			x							
Black Brant			x		x								
White-fronted Goose			x										
Snow Goose			x		x								
Mallard	x	x	x		x	x			x			x	
Gadwall			x										
Northern Pintail		x	x	x	x	x	x					x	
American Green-winged Teal		x	x		x	x							
European Wigeon			x		x	x							
American Wigeon	x	x	x	x	x	x	x					x	x
Northern Shoveler			x		x								
Canvasback					x	x							
Greater Scaup		x	x		x	x	x					x	x
Common Goldeneye			x		x	x							
Barrow's Goldeneye			x			x							
Bufflehead		x	x		x	x					x	x	x
Oldsquaw		x	x		x	x	x				x	x	x
Harlequin Duck		x	x	x	x	x	x	x	x	x	x	x	x
White-winged Scoter	x	x	x	x	x	x	x	x	x	x	x	x	x
Surf Scoter	x	x	x	x	x	x	x	x	x	x	x	x	x
Black Scoter		x	x		x	x	x			x		x	x
Ruddy Duck			x		x	x							

TABLE C-3 (continued).

	Region												
Species	1	2	3	4	5	6	7	8	9	10	11	12	13
Hooded Merganser		x	x		x	x					x	x	
Common Merganser		x	x		x	x	x		x		x	x	x
Red-breasted Merganser		x	x		x	x	x	x	x	x	x	x	x
HAWKS AND EAGLES													
Golden Eagle											x		
Bald Eagle		x	x		x	x	x	x	x	x	x	x	x
OSPREYS													
Osprey		x			x	x					x		
FALCONS													
Peregrine Falcon			x										
Merlin												x	
RAILS													
American Coot		x	x		x	x							
OYSTERCATCHERS													
Black Oystercatcher		x	x		x	x		x	x		x	x	x
PLOVERS													
Semipalmated Plover		x	x		x	x							
Killdeer		x	x	x	x	x	x	x	x			x	
American Golden Plover					x								
Black-bellied Plover		x	x		x	x							

TABLE C-3 (continued).

Species	Region 1	2	3	4	5	6	7	8	9	10	11	12	13
SANDPIPERS AND OTHER SHOREBIRDS													
Ruddy Turnstone		x	x		x								
Black Turnstone		x	x		x	x			x	x		x	
Common Snipe		x	x										
Whimbrel		x	x			x						x	
Spotted Sandpiper		x	x		x	x		x			x		
Greater Yellowlegs		x	x		x	x							
Lesser Yellowlegs		x	x		x	x							
Wandering Tattler		x	x		x								
Surfbird		x	x		x	x		x	x	x			
Red Knot			x										
Pectoral Sandpiper		x											
Baird's Sandpiper			x		x	x							
Least Sandpiper		x	x		x	x							
Dunlin		x	x		x	x							
Western Sandpiper		x	x	x	x	x						x	x
Sanderling		x	x	x	x	x	x						
Short-billed Dowitcher		x	x		x	x						x	
Long-billed Dowitcher			x										
Marbled Godwit			x			x							
PHALAROPES													
Red Phalarope	x		x										
Northern Phalarope	x	x	x	x			x	x	x	x	x		x
JAEGERS AND SKUAS													
Pomarine Jaeger	x												
Parasitic Jaeger	x		x	x	x	x	x	x	x	x	x	x	x
Long-tailed Jaeger											x		
Skua	x												

TABLE C-3 (continued).

	Region												
Species	1	2	3	4	5	6	7	8	9	10	11	12	13
GULLS AND TERNS													
Glaucous-winged Gull	x	x	x	x	x	x	x	x	x	x	x	x	x
Western Gull	x	x	x			x	x	x					x
Herring Gull	x	x	x	x	x	x	x	x	x	x	x		x
Thayer's Gull			x	x		x	x	x			x	x	x
California Gull	x	x	x	x	x	x	x	x	x	x	x	x	x
Ring-billed Gull		x	x		x	x	x		x				
Mew Gull	x	x	x	x	x	x	x	x	x	x	x	x	x
Franklin's Gull		x			x								x
Bonaparte's Gull	x	x	x	x	x	x	x	x	x	x	x	x	x
Little Gull											x		
Heermann's Gull	x	x	x	x	x	x	x	x	x	x	x	x	x
Black-legged Kittiwake	x												
Sabine's Gull	x	x											
Common Tern	x	x	x	x	x	x	x	x	x	x	x	x	x
Arctic Tern	x										x		
Caspian Tern		x	x		x	x							
ALCIDS													
Common Murre	x	x	x	x	x	x	x	x	x	x	x	x	x
Pigeon Guillemot	x	x	x	x	x	x	x	x	x	x	x	x	x
Marbled Murrelet	x	x		x	x	x	x	x	x	x	x	x	x
Ancient Murrelet	x		x										x
Cassin's Auklet	x		x										
Rhinoceros Auklet	x	x	x	x	x	x	x	x	x	x	x	x	x
Tufted Puffin	x	x	x	x									

TABLE C-4. REGIONAL OCCURRENCES OF BIRD SPECIES IN WINTER 1978 AND 1979

Species	Region 1*	2	3	4	5	6	7	8	9	10	11	12	13
LOONS													
Common Loon		x	x	x	x	x	x	x	x	x	x	x	x
Yellow-billed Loon			x		x		x	x					x
Arctic Loon		x	x	x	x	x	x	x	x	x	x	x	x
Red-throated Loon		x	x	x	x	x	x	x	x	x	x	x	x
GREBES													
Red-necked Grebe		x	x	x	x	x	x	x	x	x	x	x	x
Horned Grebe		x	x	x	x	x	x	x	x	x	x	x	x
Eared Grebe		x	x		x	x	x				x	x	
Western Grebe		x	x	x	x	x	x	x	x	x	x	x	x
Pied-billed Grebe			x		x	x					x	x	
STORM-PETRELS													
Fork-tailed Storm-Petrel		x											
CORMORANTS													
Double-crested Cormorant		x	x	x	x	x	x	x	x	x	x	x	x
Brandt's Cormorant		x	x	x	x	x	x	x	x	x	x	x	x
Pelagic Cormorant		x	x	x	x	x	x	x	x	x	x	x	x
HERONS AND BITTERNS													
Great Blue Heron		x	x	x	x	x	x	x	x	x	x	x	x
SWANS, GEESE, AND DUCKS													
Whistling Swan			x		x	x							
Trumpeter Swan					x								
Canada Goose			x		x	x	x					x	

TABLE C-4 (continued).

Species	Region 1*	2	3	4	5	6	7	8	9	10	11	12	13
American Brant			x		x								
Black Brant		x	x	x	x	x	x	x	x	x	x	x	x
White-fronted Goose						x							
Snow Goose			x		x								
Mallard		x	x	x	x	x	x				x	x	
Gadwall			x		x								
Northern Pintail		x	x		x	x				x	x	x	
American Green-winged Teal		x	x		x	x	x						
Blue-winged Teal			x										
European Wigeon			x		x	x							
American Wigeon		x	x		x	x	x	x			x	x	x
Northern Shoveler			x		x							x	
Canvasback			x		x	x	x					x	
Greater Scaup		x	x	x	x	x	x	x	x	x	x	x	x
Lesser Scaup		x	x		x							x	
Common Goldeneye		x	x	x	x	x	x	x	x	x	x	x	x
Barrow's Goldeneye			x	x	x	x	x		x			x	x
Bufflehead		x	x	x	x	x	x	x	x	x	x	x	x
Oldsquaw		x	x	x	x	x	x	x	x	x	x	x	x
Harlequin Duck		x	x	x	x	x	x	x	x	x	x	x	x
King Eider							x						
White-winged Scoter		x	x	x	x	x	x	x	x	x	x	x	x
Surf Scoter		x	x	x	x	x	x	x	x	x	x	x	x
Black Scoter		x	x	x	x	x	x	x	x	x	x	x	x
Ruddy Duck			x		x	x	x		x			x	
Hooded Merganser		x	x		x	x					x	x	x
Common Merganser		x	x		x	x	x	x	x	x	x	x	x
Red-breasted Merganser		x	x	x	x	x	x	x	x	x	x	x	x

TABLE C-4 (continued).

Species	Region 1*	2	3	4	5	6	7	8	9	10	11	12	13
HAWKS AND EAGLES													
Golden Eagle			x		x						x		
Bald Eagle		x	x		x	x	x	x	x	x	x	x	x
OSPREYS													
Osprey						x							
FALCONS													
Peregrine Falcon			x		x	x					x		
Merlin			x		x	x		x					
RAILS													
American Coot		x	x		x	x							
OYSTERCATCHERS													
Black Oystercatcher		x	x		x	x		x	x	x	x	x	x
PLOVERS													
Killdeer		x	x		x	x	x		x	x		x	
Black-bellied Plover		x	x		x	x			x	x		x	x
SANDPIPERS AND OTHER SHOREBIRDS													
Ruddy Turnstone			x			x			x				
Black Turnstone		x	x		x	x	x	x	x	x	x	x	x
Common Snipe			x										
Whimbrel			x										
Spotted Sandpiper			x		x	x			x				
Greater Yellowlegs		x	x			x						x	
Willet			x										
Surfbird		x	x		x	x		x	x	x			x

TABLE C-4 (continued).

	Region												
Species	1*	2	3	4	5	6	7	8	9	10	11	12	13
Rock Sandpiper		x	x		x				x	x			
Least Sandpiper			x		x								
Dunlin		x	x		x	x	x		x		x	x	x
Western Sandpiper			x		x	x							
Sanderling		x	x	x	x	x	x			x	x	x	
Long-billed Dowitcher			x										
PHALAROPES													
Red Phalarope		x	x										
Northern Phalarope		x	x										
JAEGERS AND SKUAS													
Parasitic Jaeger			x	x	x	x							
GULLS AND TERNS													
Glaucous Gull			x			x							
Glaucous-winged Gull		x	x	x	x	x	x	x	x	x	x	x	x
Western Gull		x	x			x	x				x		
Herring Gull		x	x	x		x	x	x			x		x
Thayer's Gull		x	x	x	x	x	x	x	x	x	x	x	x
California Gull		x	x	x	x	x		x	x		x		x
Ring-billed Gull		x	x		x	x						x	
Mew Gull		x	x	x	x	x	x	x	x	x	x	x	x
Franklin's Gull					x								
Bonaparte's Gull		x	x	x	x	x	x	x	x	x	x	x	x
Heermann's Gull		x	x	x	x	x	x	x	x		x	x	x
Black-legged Kittiwake		x	x						x				
Common Tern					x	x							

TABLE C-4 (continued).

Species	Region 1*	2	3	4	5	6	7	8	9	10	11	12	13
ALCIDS													
Common Murre		x	x	x	x	x	x	x	x	x	x	x	x
Pigeon Guillemot		x	x	x	x	x	x	x	x	x	x	x	x
Marbled Murrelet		x	x	x	x	x	x	x	x	x	x	x	x
Ancient Murrelet		x	x	x	x	x	x	x	x	x	x	x	x
Cassin's Auklet		x											
Rhinoceros Auklet		x	x	x	x	x	x	x	x	x	x	x	x
Tufted Puffin			x										

Note: *Not censused during period.

TABLE C-5. TAXONOMIC LIST OF SPECIES OBSERVED IN STUDY AREA, 1978 AND 1979

LOONS	Gaviidae
Common Loon	*Gavia immer*
Yellow-billed Loon	*G. adamsii*
Arctic Loon	*G. arctica*
Red-throated Loon	*G. stellata*
GREBES	Podicipedidae
Red-necked Grebe	*Podiceps grisegena*
Horned Grebe	*P. auritus*
Eared Grebe	*P. nigricollis*
Western Grebe	*Aechmophorus occidentalis*
Pied-billed Grebe	*Podilymbus podiceps*
ALBATROSSES	Diomedeidae
Black-footed Albatross	*Diomedea nigripes*
SHEARWATERS AND FULMARS	Procellariidae
Northern Fulmar	*Fulmarus glacialis*
Pink-footed Shearwater	*Puffinus creatopus*
Buller's Shearwater	*P. bulleri*
Sooty Shearwater	*P. griseus*
STORM-PETRELS	Hydrobatidae
Fork-tailed Storm-Petrel	*Oceanodroma furcata*
CORMORANTS	Phalacrocorax
Double-crested Cormorant	*Phalacrocorax auritus*
Brandt's Cormorant	*P. penicillatus*
Pelagic Cormorant	*P. pelagicus*
HERONS AND BITTERNS	Ardeidae
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides virescens*
American Bittern	*Botaurus lentiginosus*
SWANS, GEESE, AND DUCKS	Anatidae
Whistling Swan	*Olor columbianus*
Trumpeter Swan	*O. buccinator*
Canada Goose	*Branta canadensis*
American Brant	*B. bernicla hrota*
Black Brant	*B. bernicla nigricans*
White-fronted Goose	*Anser albifrons*
Snow Goose	*Chen caerulescens*

TABLE C-5 (continued).

SWANS, GEESE, AND DUCKS	Anatidae
Mallard	*Anas platyrhynchos*
Gadwall	*A. strepera*
Northern Pintail	*A. acuta*
American Green-winged Teal	*A. crecca carolinensis*
Blue-winged Teal	*A. discors*
European Wigeon	*A. penelope*
American Wigeon	*A. americana*
Northern Shoveler	*A. clypeata*
Canvasback	*Aythya valisineria*
Greater Scaup	*A. marila*
Lesser Scaup	*A. affinis*
Common Goldeneye	*Bucephala clangula*
Barrow's Goldeneye	*B. islandica*
Bufflehead	*B. albeola*
Oldsquaw	*Clangula hyemalis*
Harlequin Duck	*Histrionicus histrionicus*
King Eider	*Somateria spectabilis*
White-winged Scoter	*Melanitta deglandi*
Surf Scoter	*M. perspicillata*
Black Scoter	*M. nigra*
Ruddy Duck	*Oxyura jamaicensis*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Red-breasted Merganser	*M. serrator*
HAWKS AND EAGLES	Accipitridae
Golden Eagle	*Aquila chrysaetos*
Bald Eagle	*Haliaeetus leucocephalus*
OSPREYS	Pandionidae
Osprey	*Pandion haliaetus*
FALCONS	Falconidae
Peregrine Falcon	*Falco peregrinus*
Merlin	*F. columbarius*
RAILS	Rallidae
American Coot	*Fulica americana*
OYSTERCATCHERS	Haematopodidae
Black Oystercatcher	*Haematopus bachmani*
PLOVERS	Charadriidae
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer	*C. vociferus*

TABLE C-5 (continued)

PLOVERS	Charadriidae
American Golden Plover	*Pluvialis dominica*
Black-bellied Plover	*P. squatarola*
SANDPIPERS AND OTHER SHOREBIRDS	Scolopacidae
Ruddy Turnstone	*Arenaria interpres*
Black Turnstone	*A. melanocephala*
Common Snipe	*Capella gallinago*
Long-billed Curlew	*Numenius americanus*
Whimbrel	*N. phaeopus*
Spotted Sandpiper	*Actitis macularia*
Greater Yellowlegs	*Tringa melanoleucus*
Lesser Yellowlegs	*T. flavipes*
Wandering Tattler	*Heteroscelus incanum*
Willet	*Catoptrophorus semipalmatus*
Surfbird	*Aphriza virgata*
Red Knot	*Calidris canutus*
Rock Sandpiper	*C. ptilocnemis*
Pectoral Sandpiper	*C. melanotos*
Baird's Sandpiper	*C. bairdii*
Least Sandpiper	*C. minutilla*
Dunlin	*C. alpina*
Western Sandpiper	*C. mauri*
Sanderling	*C. alba*
Short-billed Dowitcher	*Limnodromus griseus*
Long-billed Dowitcher	*L. scolopaceus*
Marbled Godwit	*Limosa fedoa*
PHALAROPES	Phalaropodidae
Red Phalarope	*Phalaropus fulicarius*
Northern Phalarope	*Lobipes lobatus*
JAEGERS AND SKUAS	Stercorariidae
Pomarine Jaeger	*Stercorarius pomarinus*
Parasitic Jaeger	*S. parasiticus*
Long-tailed Jaeger	*S. longicaudus*
Skua	*Catharacta skua*
GULLS AND TERNS	Laridae
Glaucous Gull	*Larus hyperboreus*
Glaucous-winged Gull	*L. glaucescens*
Western Gull	*L. occidentalis*
Herring Gull	*L. argentatus*
Thayer's Gull	*L. thayeri*
California Gull	*L. californicus*
Ring-billed Gull	*L. delawarensis*

TABLE C-5 (continued)

GULLS AND TERNS	Laridae
Mew Gull	*L. canus*
Franklin's Gull	*L. pipixcan*
Bonaparte's Gull	*L. philadelphia*
Little Gull	*L. minutus*
Heermann's Gull	*L. heermanni*
Black-legged Kittiwake	*Rissa tridactyla*
Sabine's Gull	*Xema sabini*
Common Tern	*Sterna hirundo*
Arctic Tern	*S. paradisaea*
Caspian Tern	*S. caspia*
AUKS, MURRES, AND PUFFINS	Alcidae
Common Murre	*Uria aalge*
Thick-billed Murre	*U. lomvia*
Pigeon Guillemot	*Cepphus columba*
Marbled Murrelet	*Brachyramphus marmoratus*
Ancient Murrelet	*Synthliboramphus antiquus*
Cassin's Auklet	*Ptychoramphus aleuticus*
Rhinoceros Auklet	*Cerorhinca monocerata*
Tufted Puffin	*Lunda cirrhata*

APPENDIX G

REGIONAL AND SUBREGIONAL SUMMARIES, 1978

Seasonal monthly grouping for 1978 are as follows: Spring--April and May, 1978; Summer--June, 1978; Fall--July, August, September, and October, 1978; and Winter--November and December, 1978, and January, February, and March, 1979.

TABLE G-1. SWIFTSURE BANK REGION (01--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0101	Swiftsure Bank	Region total	D PT BOI BOI/km²	*	*	51.0 43,000 830 1.0	*

*No data are available.

TABLE 5-2. STRAIT OF JUAN DE FUCA--OUTER REGION (02--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0201	Strait of Juan de Fuca--Outer	Offshore	D	2.1		69.5	21.4
			PT	3,900	*	130,000	40,000
			BOI	100		3,700	1,300
			BOI/km^2	<0.1		2.0	0.7
0202	Vancouver Island	Nearshore	D	85.6		255.2	
			PT	4,400	*	13,000	*
			BOI	90		230	
			BOI/km^2	1.8		4.6	
0203	Cape Flattery	Nearshore	D	737.1		1,646.9	440.5
			PT	4,000	*	8,900	2,400
			BOI	78		160	45
			BOI/km^2	14.5		30.4	8.3
0204	Neah Bay	Nearshore	D	120.5	54.7	270.5	144.1
			PT	540	250	1,200	650
			BOI	9.2	4.6	20	11
			BOI/km^2	2.0	1.0	4.4	2.3
0205	Neah Bay to Clallam Bay	Nearshore	D	86.1		370.8	259.2
			PT	1,100	*	4,800	3,300
			BOI	23		90	56
			BOI/km^2	1.8		7.0	4.3
0206	Clallam Bay	Nearshore	D	52.0	30.0	194.1	68.3
			PT	170	96	620	220
			BOI	3.2	2.3	7.4	4.2
			BOI/km^2	1.0	0.7	2.3	1.3

TABLE 6-2 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0207	Clallan Bay to Crescent Bay	Nearshore	D	158.7	35.5	200.1	258.2
			PT	3,300	740	4,200	5,400
			BOI	81	17	54	78
			BOI/km^2	3.9	0.8	2.6	3.7
0208	Crescent Bay	Nearshore	D	217.0	*	181.9	212.5
			PT	240		200	230
			BOI	5.2		2.6	4.3
			BOI/km^2	4.8		2.4	3.9
0209	Crescent Bay to Ediz Hook	Nearshore	D	538.6	*	408.5	890.3
			PT	4,800		3,700	8,000
			BOI	70		63	130
			BOI/km^2	6.3		7.0	14.9
		Region total	D	12.0		85.3	30.1
			PT	24,000	1,100	170,000	60,000
			BOI	460	24	4,400	1,600
			BOI/km^2	0.2		2.2	0.8

*No data are available.

TABLE 6-3. STRAIT OF JUAN DE FUCA--INNER REGION (03--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0301	Strait of Juan de Fuca--Inner	Offshore	D	8.4	2.5	19.0	27.3
			PT	14,000	4,100	31,000	45,000
			BOI	390	130	740	900
			BOI/km^2	0.3	<0.1	0.4	0.6
0302	Ediz Hook	Nearshore	D	34.1	11.4	76.6	41.7
			PT	10	5	31	17
			BOI	0.32	0.12	0.65	0.30
			BOI/km^2	0.8	0.3	1.6	0.8
0303	Port Angeles	Nearshore	D	65.3	30.2	270.3	203.3
			PT	680	310	2,800	2,100
			BOI	14.4	6.8	40	39
			BOI/km^2	1.4	0.6	3.9	3.8
0304	Voice of America	Nearshore	D	128.2	130.4	198.3	141.9
			PT	3,100	3,100	4,800	3,400
			BOI	76	71	91	52
			BOI/km^2	7.3	2.9	3.8	2.2
0305	Dungeness Spit	Nearshore	D	161.0		1,067.3	1,046.0
			PT	640	*	4,300	4,200
			BOI	14		61	32
			BOI/km^2	1.4		15.2	8.0
0306	Dungeness Bay/ Harbor	Nearshore	D	512.0	119.8	563.5	565.0
			PT	6,100	1,400	6,800	6,800
			BOI	120	25	85	78
			BOI/km^2	12	2.1	7.1	6.5

TABLE G-3 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0307	Jamestown	Nearshore	D	789.4	*	1,887.4	1,014.6
			PT	17,000		40,000	2,200
			BOI	350		350	260
			BOI/km^2	16.3		16.2	12.1
0308	Sequim Bay	Nearshore	D	203.4	*	363.5	272.7
			PT	2,400		4,300	3,200
			BOI	40		68	45
			BOI/km^2	3.4		5.7	3.8
		Offshore	D	140.0	*	400.7	161.2
			PT	280		800	320
			BOI	6.3		22	6.0
			BOI/km^2	3.2		10.8	3.0
		Sum	D	201.9	*	365.3	269.1
			PT	2,700		5,100	3,500
			BOI	46		89	51
			BOI/km^2	3.3		6.4	3.7
0309	Miller Peninsula	Nearshore	D	116.8	*	142.4	570.9
			PT	560		680	2,700
			BOI	12		11	51
			BOI/km^2	2.6		2.2	10.7
0310	Protection Island	Nearshore	D	169.1	*	1,736.5	1,150.0
			PT	2,400		5,400	3,600
			BOI	54		100	61
			BOI/km^2	17.5		32.1	19.5

TABLE G-3 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0311	Discovery Bay	Nearshore	D	177.6	14.0	102.8	429.9
			PT	1,900	150	1,100	4,600
			BOI	42	3.3	22	86
			BOI/km^2	3.2	0.3	1.7	6.6
		Offshore	D	112.0		82.6	224.5
			PT	2,700		2,000	5,400
			BOI	72.3		55	130
			BOI/km^2	3.0		2.3	5.5
		Sum	D	146.2		86.0	287.3
			PT	4,600		3,100	10,000
			BOI	110		77	220
			BOI/km^2	3.1		2.1	6.3
0312	Quimper Peninsula	Nearshore	D	170.2	*	715.4	728.1
			PT	1,800		7,700	7,800
			BOI	34		110	130
			BOI/km^2	3.2		10.1	11.9
0313	Whidbey Island	Nearshore	D	*	*	115.4	127.8
			PT			2,400	2,700
			BOI			44	45
			BOI/km^2			2.1	2.1
0314	Smith Island	Nearshore	D	1,436.7	*	1,430.0	6,969.2
			PT	430		430	2,100
			BOI	12		8.4	16
			BOI/km^2	40.3		27.9	52.0

TABLE G-3 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0315	Deception Pass	Nearshore	D	51.1	64.2	175.2	98.8
			PT	290	360	980	550
			BOI	7.0	11	21	12
			BOI/km^2	1.2	2.0	3.8	2.2
0316	Lopez Island (south shore)	Nearshore	D	1,047.8	*	1,286.4	324.8
			PT	9,300		11,000	2,900
			BOI	180		220	54
			BOI/km^2	20.6		24.9	6.0
0317	San Juan Island (south shore)	Nearshore	D	258.5	*	732.0	312.3
			PT	910		2,600	1,100
			BOI	11		42	15
			BOI/km^2	3.3		12.0	4.3
0318	Victoria, Vancouver Island	Nearshore	D	*	*	*	*
			PT				
			BOI				
			BOI/km^2				
		Region total	D	35.7	5.2	71.5	55.0
			PT	65,000	9,400	130,000	100,000
			BOI	1,500	250	2,900	2,000
			BOI/km^2	0.8	0.1	1.6	1.1

*No data are available.

TABLE G-4. ADMIRALTY INLET REGION (04--), SUMMARIES OF SUBREGIONS, 1978

Subregion			Season			
Code	Name	Area	Spring	Summer	Fall	Winter

The data for this region are not compatible with those of 1979, due to differences in census methods.

TABLE G-5. ANACORTES TO HALES PASSAGE REGION (05--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0501	Bellinghan Channel	Nearshore	D	224.6	240.9	413.0	419.8
			PT	1,100	1,100	1,900	2,000
			BOI	20	23	34	30
			BOI/km^2	4.3	4.9	7.3	6.3
		Offshore	D	56.6		164.2	120.9
			PT	3,900		11,000	8,300
			BOI	84		330	190
			BOI/km^2	1.2		4.8	2.8
		Sum	D	60.9		175.9	135.3
			PT	4,500		13,000	10,000
			BOI	100		360	220
			BOI/km^2	1.4		4.9	3.0
0502	Guemes Channel	Nearshore	D	101.4			181.5
			PT	1,000			1,900
			BOI	24	*	*	42
			BOI/km^2	2.4			4.1
0503	Fidalgo Bay	Nearshore	D	173.8	33.2	107.1	353.7
			PT	2,000	380	1,200	4,100
			BOI	49	6.8	19	52
			BOI/km^2	4.3	0.6	1.6	4.6
0504	Padilla Bay	Nearshore	D	290.9	45.5	191.4	345.5
			PT	16,000	2,500	11,000	19,000
			BOI	460	48	100	350
			BOI/km^2	8.4	0.9	1.9	6.3

TABLE G-5 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0504	Padilla Bay	Offshore	D	1,240.0		1,019.2	2,864.2
			PT	31,000		25,000	72,000
			BOI	620		400	1,100
			BOI/km^2	24.7		16.2	43.3
		Sum	D	587.5		450.0	1,137.5
			PT	47,000		36,000	91,000
			BOI	1,100		510	1,400
			BOI/km^2	13.8		6.4	17.5
0505	Samish Bay	Nearshore	D	379.3	38.4	581.9	698.2
			PT	11,000	1,100	17,000	20,000
			BOI	440	13	190	250
			BOI/km^2	15.4	0.5	6.5	8.6
		Offshore	D	567.4		224.0	995.1
			PT	21,000		8,300	37,000
			BOI	480		230	540
			BOI/km^2	13.0		6.2	14.6
		Sum	D	500		378.8	863.6
			PT	33,000		25,000	57,000
			BOI	930		420	790
			BOI/km^2	14.1		6.4	12.0
0506	Bellingham Bay	Nearshore	D	97.2	52.9	78.4	143.8
			PT	3,500	1,900	2,800	5,200
			BOI	62	38	56	85
			BOI/km^2	1.7	1.1	1.5	2.4

TABLE G-5 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0506	Bellingham Bay	Offshore	D	67.2	4.0	115.5	324.0
			PT	8,200	490	14,000	40,000
			BOI	200	9.4	400	1,100
			BOI/km^2	1.7	<0.1	3.3	9.0
		Sum	D	75.2	45.1	107.6	284.8
			PT	12,000	2,400	17,000	45,000
			BOI	266	47	460	1,200
			BOI/km^2	1.7	0.3	2.9	7.6
0507	Hales Passage	Nearshore	D	126.2	18.4	26.2	60.2
			PT	2,000	300	420	970
			BOI	30	7.4	7.9	17
			BOI/km^2	1.9	0.5	0.5	1.1
		Region total	D	240.6	28.9	221.3	505.2
			PT	100,000	12,000	92,000	210,000
			BOI	2,500	150	1,800	3,700
			BOI/km^2	6.0	0.4	4.3	8.9

[a] No data are available.

TABLE G-6. GEORGIA STRAIT--EASTERN REGION (06--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0601	Lummi Bay	Nearshore	D	2,346.4	13.7	233.4	855.4
			PT	42,000	230	4,000	15,000
			BOI	550	3.8	40	120
			BOI/km^2	30.6	0.2	2.3	7.1
		Offshore	D	925.0		137.7	204.2
			PT	7,400		1,100	1,600
			BOI	160		22	26
			BOI/km^2	20.0		2.8	3.3
		Sum	D	1,960.0		204.0	640.0
			PT	49,000		5,100	16,000
			BOI	710		62	150
			BOI/km^2	28.4		2.5	6.0
0602	Cherry Point	Nearshore	D	1,695.7	31.5	35.9	117.8
			PT	24,000	440	510	1,700
			BOI	580	10	10	30
			BOI/km^2	41.4	0.7	0.7	2.1
0603	Birch Bay	Nearshore	D	755.6	44.7	388.4	379.8
			PT	6,800	400	3,500	3,400
			BOI	150	7.8	56	55
			BOI/km^2	17.2	0.9	6.2	6.1
		Offshore	D	270.0		71.0	210.5
			PT	2,700		700	2,100
			BOI	56		17	43
			BOI/km^2	5.6		1.7	4.3

TABLE G-6 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0603	Birch Bay	Sum	D	500.0		221.1	289.5
			PT	9,500		4,200	5,500
			BOI	210		73	98
			BOI/km^2	11.1		3.8	5.2
0604	Semiahmoo Spit	Nearshore	D	1,147.4	74.4	853.7	1,318.7
			PT	11,000	710	8,100	13,000
			BOI	220	10	210	190
			BOI/km^2	23.2	1.1	22.6	19.8
0605	Drayton Harbor	Nearshore	D	355.4	85.6	532.1	856.7
			PT	4,500	1,100	6,800	11,000
			BOI	68	16	73	130
			BOI/km^2	5.3	1.3	5.7	10.1
0606	Boundary Bay	Nearshore	D				486.7
			PT				36,000
			BOI				580
			BOI/km^2				7.8
		Offshore	D	231.7	*	118.1	615.5
			PT	19,000		9,700	50,000
			BOI	290		230	1,100
			BOI/km^2	4.2		2.9	13.0
		Sum	D				554.1
			PT				87,000
			BOI				1,700
			BOI/km^2				10.8

TABLE G-6 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0607	San Juan Islands--Northern Tier	Nearshore	D	151.7	75.7	388.2	274.0
			PT	760	380	1,900	1,400
			BOI	12	9.0	34	27
			BOI/km^2	2.5	1.8	6.8	5.3
		Offshore	D	116.7	1.4	30.0	408.3
			PT	3,400	42	880	12,000
			BOI	55	0.79	26	280
			BOI/km^2	1.9	<0.1	0.9	9.4
		Sum	D	122.0	12.2	81.4	377.6
			PT	4,200	420	2,800	13,000
			BOI	68	9.8	60	300
			BOI/km^2	2.0	0.3	1.7	8.7
0608	Georgia Strait	Offshore	D	45	*	90.9	88.2
			PT	13,000		26,000	25,000
			BOI	280		570	590
			BOI/km^2	1.0		2.0	2.0
		Region total	D	250.0	5.9	112.5	303.5
			PT	140,000	3,300	63,000	170,000
			BOI	2,500	58	1,300	3,100
			BOI/km^2	4.5	1.0	2.3	5.5

*No data are available.

TABLE G-7. GEORGIA STRAIT--WESTERN REGION (07--), SUMMARIES OF SUBREGION, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0701	Pt. Roberts	Nearshore	D	489.1	14.4	142.2	377.9
			PT	8,000	720	2,300	6,200
			BOI	180	16	39	110
			BOI/km^2	11.0	1.0	2.4	6.7
0702	Tsawwassen Bay	Nearshore	D	2,130.6	233.1	476.6	458.4
			PT	13,000	1,400	2,900	2,800
			BOI	260	27	44	37
			BOI/km^2	42.6	4.5	7.2	6.1
0703	Georgia Strait	Offshore	D	8.0	1.2	2.9	11.5
			PT	2,900	440	1,100	4,200
			BOI	63	8.3	16	82
			BOI/km^2	0.2	<0.1	<0.1	0.2
		Region total	D	62.0	6.5	16.3	33.6
			PT	24,000	2,500	6,300	13,000
			BOI	500	51	99	230
			BOI/km^2	1.3	0.1	0.3	0.6

TABLE G-8. HARO STRAIT REGION (08--), SUMMARIES OF SUBREGION, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0801	Northern Haro Strait	Nearshore	D	179.7	179.6	367.1	312.5
			PT	1,700	1,700	3,500	3,000
			BOI	31	53	60	48
			BOI/km^2	3.3	5.5	6.3	5.0
		Offshore	D	3.3	7.1	68.7	28.3
			PT	1,100	2,300	23,000	9,300
			BOI	23	55	260	170
			BOI/km^2	0.1	0.2	0.8	0.5
		Sum	D	8.3	11.8	76.8	35.4
			PT	2,800	4,000	26,000	12,000
			BOI	55	110	320	220
			BOI/km^2	0.2	0.3	0.9	0.6
0802	Southern Haro Strait	Nearshore	D	50.7		292.4	102.3
			PT	250		1,500	510
			BOI	3.8		23	8.2
			BOI/km^2	0.8		4.6	1.6
		Offshore	D	4.8	1.3	4.5	11.9
			PT	1,100	290	990	2,600
			BOI	23	7.5	22	55
			BOI/km^2	0.1	<0.1	0.1	0.3
		Sum	D	6.2		11.1	13.8
			PT	1,400		2,500	3,100
			BOI	27		45	63
			BOI/km^2	0.1		0.2	0.3

TABLE G-8 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0802	Southern Haro Strait	Region total	D	7.5	7.6	51.5	28.4
			PT	4,200	4,300	29,000	16,000
			BOI	82	120	370	280
			BOI/km^2	0.1	0.2	0.7	0.5

TABLE G-9. ROSARIO STRAIT REGION (09--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0901	Southern Rosario Strait	Nearshore	D	95.4	103.7	366.3	207.5
			PT	1,000	1,100	4,000	2,200
			BOI	21	30	87	54
			BOI/km^2	1.9	2.8	8.1	5.0
		Offshore	D	7.1	3.0	59.2	85.2
			PT	800	340	6,700	9,600
			BOI	17	5.6	150	250
			BOI/km^2	0.2	<0.1	1.3	2.3
		Sum	D	14.6	12.2	89.3	97.4
			PT	1,800	1,500	11,000	12,000
			BOI	38	36	230	310
			BOI/km^2	0.3	0.3	1.9	2.5
0902	Central Rosario Strait	Nearshore	D	117.1	*	572.0	365.7
			PT	430		2,100	1,400
			BOI	7.7		34	18
			BOI/km^2	2.1		9.1	4.9
		Offshore	D	12.0	*	216.5	112.3
			PT	950		17,000	8,900
			BOI	24		360	210
			BOI/km^2	0.3		4.5	2.6
		Sum	D	16.8	*	228.6	120.3
			PT	1,400		19,000	10,000
			BOI	32		390	230
			BOI/km^2	0.4		4.7	2.8

TABLE G-9 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0903	Northern Rosario Strait	Nearshore	D	455.3	128.8	259.6	251.4
			PT	1,500	420	860	830
			BOI	26	8.7	13	13
			BOI/km^2	7.8	2.6	3.9	4.0
		Offshore	D	74.4	4.2	137.9	51.3
			PT	6,600	370	12,000	4,600
			BOI	130	7.1	320	120
			BOI/km^2	1.4	<0.1	3.6	1.4
		Sum	D	87.8	8.7	141.0	58.6
			PT	8,100	800	13,000	5,400
			BOI	150	16	330	140
			BOI/km^2	1.6	0.2	3.6	1.5
		Region total	D	36.8	7.7	144.1	90.5
			PT	11,000	2,300	43,000	27,000
			BOI	220	52	950	670
			BOI/km^2	0.7	0.2	3.2	2.2

*No data are available.

TABLE G-10. SAN JUAN ISLANDS--NORTHERN WATERS REGION (10--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1001	President Channel	Nearshore	D	157.2		209.9	219.6
			PT	500	*	670	700
			BOI	9.6		11	12
			BOI/km^2	3.0		3.5	3.7
		Offshore	D	8.6		21.2	35.0
			PT	860	*	2,100	3,500
			BOI	19		51	76
			BOI/km^2	0.2		0.5	0.8
		Sum	D	13.5		27.0	40.5
			PT	1,400	*	2,800	4,200
			BOI	29		62	88
			BOI/km^2	0.3		0.6	0.8
1002	Northern Areas	Nearshore	D	15.7		138.7	64.4
			PT	30	*	280	130
			BOI	0.64		3.4	2.3
			BOI/km^2	0.3		1.7	1.2
		Offshore	D	39.2		43.8	130
			PT	1,900	*	2,100	6,300
			BOI	29		35	120
			BOI/km^2	0.6		0.7	2.5

TABLE G-10 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1002	Northern Areas	Sum	D	39.0	*	48.0	128.0
			PT	1,900		2,400	6,400
			BOI	30		38	120
			BOI/km^2	0.6		0.7	2.4
		Region total	D	21.5	*	33.9	71.6
			PT	3,300		5,200	11,000
			BOI	58		100	210
			BOI/km^2	0.4		0.7	1.4

*No data are available.

TABLE G-11. SAN JUAN ISLANDS--INTERIOR CHANNELS AND PASSAGES REGION (11--), SUMMARIES OF SUBREGION, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1101	Speiden Channel	Nearshore	D	66.2		438.8	224.0
			PT	70		480	250
			BOI	1.6		7.5	4.8
			BOI/km^2	1.5		6.9	4.4
		Offshore	D	8.9	1.9	88.6	84.5
			PT	110	24	1,100	1,100
			BOI	3.4	0.52	12	20
			BOI/km^2	0.3	<0.1	1.0	1.6
		Sum	D	13.1		116.8	94.9
			PT	180		1,600	1,300
			BOI	5.0		20	24
			BOI/km^2	0.4		1.4	1.8
1102	Northern San Juan Channel	Nearshore	D			12.3	42.0
			PT			36	120
			BOI			0.38	1.5
			BOI/km^2			0.1	0.5
		Offshore	D	2.7	0.3	11.4	22.0
			PT	90	9	380	730
			BOI	2.1	0.14	5.0	19
			BOI/km^2	<0.1	<0.1	0.1	0.6

TABLE G-11 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1102	Northern San Juan Channel	Sum	D			11.5	24.5
			PT			410	850
			BOI			5.4	20
			BOI/km^2			0.1	0.6
1103	Southern San Juan Channel	Nearshore	D	280.7		470.2	159.8
			PT	1,400		2,400	800
			BOI	29		45	16
			BOI/km^2	5.8		8.9	3.2
		Offshore	D	2.3	292.0	52.5	94.5
			PT	100	13,000	2,300	4,100
			BOI	2.3	370	47	98
			BOI/km^2	<0.1	8.4	1.1	2.3
		Sum	D	30.9		94.8	101.0
			PT	1,500		4,600	4,900
			BOI	31		32	110
			BOI/km^2	0.6		1.9	2.3
1104	Wasp Pass	Nearshore	D	37.3	*	27.5	83.4
			PT	100		69	210
			BOI	2.1		1.1	4.4
			BOI/km^2	0.8		0.4	1.7
1105	Upright Channel	Offshore	D	7.5	52.2	38.6	36.2
			PT	70	460	340	320
			BOI	1.9	12	6.0	6.5
			BOI/km^2	0.2	1.4	0.7	0.7

TABLE G-11 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1106	Harney Channel	Nearshore	D	8.2		22.2	45.1
			PT	20		49	99
			BOI	0.46		0.62	1.7
			BOI/km^2	0.2		0.3	0.8
		Offshore	D	12.0	7.6	17.2	69.7
			PT	370	230	530	2,100
			BOI	8.7	4.8	11	53
			BOI/km^2	0.3	0.2	0.4	1.7
		Sum	D	11.9		17.4	64.6
			PT	390		580	2,200
			BOI	9.1		12	54
			BOI/km^2	0.3		0.4	1.6
1107	Obstruction Pass	Nearshore	D	*	*	*	291.1
			PT				730
			BOI				10.2
			BOI/km^2				4.1
1108	Thatcher Pass	Nearshore	D	7.6	3.4	48.9	29.7
			PT	36	18	260	160
			BOI	0.85	0.46	3.2	3.5
			BOI/km^2	0.9	0.5	3.6	3.9
		Region total	D	15.8		54.8	75.4
			PT	2,300		8,000	11,000
			BOI	52		140	240
			BOI/km^2	0.4		1.0	1.6

*No data are available.

TABLE G-12. SAN JUAN ISLANDS--INTERIOR BAYS REGION (12--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1201	Mosquito/Roche Complex	Nearshore	D	124.7	10.6	386.5	421.6
			PT	1,300	110	3,900	4,300
			BOI	21	2.7	74	59
			BOI/km^2	3.5	0.5	12.3	9.8
1202	Friday Harbor	Nearshore	D	12.2	3.3	116.8	346.4
			PT	20	5	180	520
			BOI	0.35	0.09	2.2	7.5
			BOI/km^2	0.2	<0.1	1.5	5.0
1203	Griffin Bay	Nearshore	D	112.0	*	*	786.7
			PT	840			5,900
			BOI	18			97
			BOI/km^2	1.5			12.9
		Offshore	D	10.9	*	*	93.5
			PT	80			700
			BOI	1.7			14
			BOI/km^2	0.2			1.9
		Sum	D	61.3	*	*	440.0
			PT	920			6,600
			BOI	19			110
			BOI/km^2	1.3			7.3
1205	Fisherman Bay	Nearshore	D	*	*	*	476.0
			PT				900
			BOI				12
			BOI/km^2				6.5

TABLE G-12 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1206	Swift's/Shoal Bays	Nearshore	D	*	*	*	116.4
			PT				540
			BOI				8.6
			BOI/km^2				1.9
1207	Deer Harbor	Nearshore	D	*	*	*	67.0
			PT				134
			BOI				1.8
			BOI/km^2				0.9
1208	West Sound	Nearshore	D	*	*	*	108.4
			PT				1,000
			BOI				26
			BOI/km^2				2.9
1209	East Sound	Nearshore	D	*	*	*	21.5
			PT				67
			BOI				1.2
			BOI/km^2				0.4
		Offshore	D				138.1
			PT				3,700
			BOI				110
			BOI/km^2				4.1
		Sum	D				128.4
			PT				3,800
			BOI				110
			BOI/km^2				3.7

TABLE G-12 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1210	Lopez Sound	Nearshore	D			305.4	336.4
			PT	*	*	7,300	8,000
			BOI			165	150
			BOI/km^2			6.9	6.1
		Region total	D	22.5	1.1	107.5	244.4
			PT	2,300	115	11,000	25,000
			BOI	41	2.8	240	480
			BOI/km^2	0.4	<0.1	2.3	4.7

*No data are available.

TABLE G-13. CANADIAN WATERS REGION (13--), SUMMARIES OF SUBREGIONS, 1978

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1301	Active Pass	Nearshore	D	674.8	12.4	89.3	304.0
			PT	7,100	130	940	3,200
			BOI	140	2.5	13	59
			BOI/km^2	12.9	0.2	1.2	5.6
1302	Canadian Gulf Islands	Offshore	D	18.1	2.6	12.1	29.9
			PT	2,600	360	1,700	4,300
			BOI	36	7.4	32	72
			BOI/km^2	0.2	<0.1	0.2	0.5
1303	Sidney Approach	Offshore	D	19.7	55.0	27.0	87.1
			PT	2,300	6,500	3,200	10,000
			BOI	55	140	57	210
			BOI/km^2	0.5	1.2	0.5	1.8
		Region total	D	148.2	25.7	31.6	100.8
			PT	12,000	7,000	5,800	18,000
			BOI	210	150	100	350
			BOI/km^2	0.8	1.4	1.9	7.9

APPENDIX H

REGIONAL AND SUBREGIONAL SUMMARIES, 1979

Seasonal monthly grouping for 1979 are as follows: Spring--April and May; Summer--June; and Fall--July, August, September, and October.

TABLE H-1. SWIFTSURE BANK REGION (01--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0101	Swiftsure Bank	Region total	D			375.8
			PT	*	*	320,000
			BOI			3,300
			BOI/km^2			4.0

*No data are available.

TABLE H-2. STRAIT OF JUAN DE FUCA--OUTER REGION (02--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0201	Strait of Juan de Fuca--Outer	Offshore	D	4.4	1.2	75.2
			PT	8,200	2,400	142,000
			BOI	200	56	4,100
			BOI/km^2	0.1	<0.1	2.2
0202	Vancouver Island	Nearshore	D			
			PT	*	*	*
			BOI			
			BOI/km^2			
0203	Cape Flattery	Nearshore	D	1,318.6	60.9	1,150.7
			PT	7,100	330	6,200
			BOI	130	6.9	120
			BOI/km^2	24.7	1.3	21.6
0204	Neah Bay	Nearshore	D	87.3	32.2	624.7
			PT	390	140	2,800
			BOI	5.6	2.1	38
			BOI/km^2	1.2	0.5	8.4
0205	Neah Bay to Clallam Bay	Nearshore	D	241.0	140.3	937.3
			PT	3,100	1,800	12,000
			BOI	57	36	170
			BOI/km^2	4.4	2.8	13.3
0206	Clallam Bay	Nearshore	D	69.6	52.5	237.5
			PT	220	170	760
			BOI	4.1	3.8	11
			BOI/km^2	1.3	1.2	3.4

TABLE H-2 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0207	Clallam Bay to Crescent Bay	Nearshore	D	101.5	37.8	632.3
			PT	2,100	790	13,000
			BOI	39	14	180
			BOI/km^2	1.9	0.7	8.4
0208	Crescent Bay	Nearshore	D	145.6	41.7	431.1
			PT	160	46	470
			BOI	3.0	1.1	6.7
			BOI/km^2	2.7	1.0	6.1
0209	Crescent Bay to Ediz Hook	Nearshore	D	288.4	57.7	726.6
			PT	2,600	520	6,500
			BOI	44	12	97
			BOI/km^2	4.9	1.4	10.8
		Region total	D	12.0	3.1	90.4
			PT	24,000	6,200	180,000
			BOI	480	130	4,700
			BOI/km^2	0.2	0.1	2.4

*No data are available.

TABLE H-3. STRAIT OF JUAN DE FUCA--INNER REGION (03--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0301	Strait of Juan de Fuca--Inner	Offshore	D	14.9	13.9	49.1
			PT	24,000	23,000	80,000
			BOI	510	550	1,900
			BOI/km^2	0.8	0.7	1.7
0302	Ediz Hook	Nearshore	D	28.3	69.0	201.9
			PT	11	28	81
			BOI	0.26	0.71	1.9
			BOI/km^2	0.6	1.8	4.9
0303	Port Angeles	Nearshore	D	71.1	37.8	265.7
			PT	740	390	2,800
			BOI	16	7.8	39
			BOI/km^2	1.5	0.8	3.7
0304	Voice of America	Nearshore	D	65.4	144.6	214.8
			PT	1,600	3,500	5,100
			BOI	37	85	100
			BOI/km^2	1.5	3.5	4.2
0305	Dungeness Spit	Nearshore	D	153.8	277.0	604.3
			PT	620	1,100	2,400
			BOI	13	22	39
			BOI/km^2	3.2	5.4	9.7
0306	Dungeness Bay/ Harbor	Nearshore	D	571.8	208.0	474.3
			PT	6,900	2,500	5,700
			BOI	130	40	70
			BOI/km^2	11.2	3.3	5.8

TABLE H-3 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0307	Jamestown	Nearshore	D	649.0	525.9	563.0
			PT	14,000	11,000	12,000
			BOI	300	200	180
			BOI/km^2	14.1	9.3	8.4
0308	Sequim Bay	Nearshore	D	207.3	2.9	147.2
			PT	2,400	34	1,700
			BOI	34	0.83	28
			BOI/km^2	2.9	<0.1	2.4
		Offshore	D	230.8	1.7	99.2
			PT	460	3	200
			BOI	6.6	0.06	4.8
			BOI/km^2	3.3	<o.1	2.4
		Sum	D	208.2	2.7	137.7
			PT	2,900	37	1,900
			BOI	40	0.90	33
			BOI/km^2	2.9	0.1	2.4
0309	Miller Peninsula	Nearshore	D	124.9	290.0	217.8
			PT	600	1,400	1,000
			BOI	14	31	19
			BOI/km^2	2.9	6.4	3.9
0310	Protection Island	Nearshore	D	1,300.0	2,680.0	1,967.5
			PT	4,100	8,300	6,100
			BOI	95	170	130
			BOI/km^2	76.2	53.5	43.0

TABLE H-3 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0311	Discovery Bay	Nearshore	D	486.2	31.1	202.2
			PT	6,300	400	2,600
			B0I	140	8.0	45
			B0I/km^2	11.0	0.6	3.5
		Offshore	D	20.6	8.0	69.7
			PT	500	190	1,700
			B0I	13	3.7	46
			B0I/km^2	0.5	0.2	1.9
		Sum	D	195.4	17.2	123.6
			PT	6,800	600	4,300
			B0I	160	12	91
			B0I/km^2	4.6	0.3	2.6
0312	Quimper Peninsula	Nearshore	D	245.0	340.8	701.2
			PT	2,600	3,600	7,500
			B0I	44	81	110
			B0I/km^2	4.1	7.6	10.5
0313	Whidbey Island	Nearshore	D	27.2	26.0	280.9
			PT	570	550	5,900
			B0I	11	15	130
			B0I/km^2	0.5	0.7	6.4
0314	Smith Island	Nearshore	D	1,210.0	2,643.3	4,453.3
			PT	360	790	1,300
			B0I	7.2	16	23
			B0I/km^2	24.0	54.4	76.0

TABLE H-3 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0315	Deception Pass	Nearshore	D	44.2	25.4	116.5
			PT	250	140	650
			BOI	5.9	3.1	13
			BOI/km^2	1.1	0.6	2.4
0316	Lopez Island (south shore)	Nearshore	D	451.6	529.9	658.1
			PT	4,000	4,700	5,900
			BOI	81	95	120
			BOI/km^2	9.1	10.7	13.2
0317	San Juan Island (south shore)	Nearshore	D	115.4	48.2	366.8
			PT	400	170	1,300
			BOI	5.7	3.0	25
			BOI/km^2	1.6	0.9	7.2
0318	Victoria, Vancouver Island	Nearshore	D			
			PT	*	*	*
			BOI			
			BOI/km^2			
		Region total	D	60.5	47.8	88.0
			PT	110,000	87,000	160,000
			BOI	2,400	1,900	3,800
			BOI/km^2	1.3	1.0	2.1

*No data are available.

TABLE H-4. ADMIRALTY INLET REGION (04--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0401	Admiralty Inlet	Region total	D	65.9	100.7	84.6
			PT	4,900	7,600	6,300
			BOI	160	330	190
			BOI/km^2	2.2	4.4	2.6

TABLE H-5. ANACORTES TO HALES PASSAGE REGION (05--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0501	Bellingham Channel	Nearshore	D	176.4	129.2	237.2
			PT	830	610	1,100
			BOI	15	12	21
			BOI/km^2	3.2	2.5	4.5
		Offshore	D	22.5	15.6	29.6
			PT	1,600	1,100	2,000
			BOI	39	25	44
			BOI/km^2	0.6	0.4	0.6
		Sum	D	32.5	23.0	41.9
			PT	2,400	1,700	3,100
			BOI	54	37	65
			BOI/km^2	0.7	0.5	0.9
0502	Guemes Channel	Nearshore	D	37.5	27.9	28.3
			PT	380	280	290
			BOI	12	10	3.7
			BOI/km^2	1.2	1.0	0.4
0503	Fidalgo Bay	Nearshore	D	116.1	26.2	99.5
			PT	1,300	300	1,100
			BOI	26	5.2	14
			BOI/km^2	2.3	0.4	1.2
0504	Padilla Bay	Nearshore	D	393.5	52.7	150.5
			PT	22,000	2,900	8,300
			BOI	460	52	120
			BOI/km^2	8.5	0.9	2.1

TABLE H-5 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0504	Padilla Bay	Offshore	D	825.0	83.9	319.6
			PT	21,000	2,100	8,000
			BOI	510	39	150
			BOI/km^2	20.6	1.5	6.0
		Sum	D	525.0	62.5	200.0
			PT	42,000	5,000	16,000
			BOI	980	90	270
			BOI/km^2	13.3	1.1	3.4
0505	Samish Bay	Nearshore	D	306.2	62.3	179.5
			PT	8,900	1,800	5,200
			BOI	140	33	75
			BOI/km^2	5.0	1.1	2.6
		Offshore	D	774.6	30.3	55.6
			PT	29,000	1,100	2,100
			BOI	660	29	45
			BOI/km^2	17.8	0.8	1.2
		Sum	D	575.8	43.9	110.6
			PT	38,000	2,900	7,300
			BOI	800	62	120
			BOI/km^2	12.1	0.9	1.8
0506	Bellingham Bay	Nearshore	D	136.9	67.9	79.1
			PT	4,900	2,400	2,800
			BOI	110	49	49
			BOI/km^2	3.0	1.4	1.4

TABLE H-5 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0506	Bellingham Bay	Offshore	D	177.3	20.0	12.9
			PT	22,000	2,400	1,600
			BOI	590	44	24
			BOI/km^2	4.8	0.4	0.2
		Sum	D	170.9	31.0	27.8
			PT	27,000	4,900	4,400
			BOI	700	93	73
			BOI/km^2	4.4	0.6	0.5
0507	Hales Passage	Nearshore	D	258.5	65.8	44.2
			PT	4,200	1,100	710
			BOI	95	38	18
			BOI/km^2	5.9	2.4	1.1
		Region total	D	228.5	43.3	84.2
			PT	95,000	18,000	35,000
			BOI	2,200	370	560
			BOI/km^2	5.3	0.9	1.3

TABLE H-6. GEORGIA STRAIT--EASTERN REGION (06--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0601	Lummi Bay	Nearshore	D	1,000.0	113.1	401.9
			PT	17,000	1,900	6,800
			BOI	210	31	74
			BOI/km^2	12.5	1.8	4.4
		Offshore	D	300.0	45.6	200.0
			PT	2,400	360	1,600
			BOI	46	6.5	30
			BOI/km^2	8.4	0.8	3.8
		Sum	D	760.0	92.0	336.0
			PT	19,000	2,300	8,400
			BOI	260	38	100
			BOI/km^2	10.4	1.5	4.0
0602	Cherry Point	Nearshore	D	1,023.5	49.7	41.4
			PT	14,000	700	580
			BOI	320	16	12
			BOI/km^2	23.0	1.1	0.9
0603	Birch Bay	Nearshore	D	599.7	115.3	375.1
			PT	5,400	1,000	3,400
			BOI	83	15	55
			BOI/km^2	9.2	1.6	6.1
		Offshore	D	63.5	30.0	53.0
			PT	640	300	530
			BOI	14	4.4	14
			BOI/km^2	1.4	0.4	1.4

TABLE H-6 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0603	Birch Bay	Sum	D	315.8	68.4	205.3
			PT	6,000	1,300	3,900
			BOI	97	19	69
			BOI/km^2	5.1	1.0	3.6
0604	Semiahmoo Spit	Nearshore	D	861.7	523.5	578.8
			PT	8,200	5,000	5,500
			BOI	170	90	130
			BOI/km^2	18.0	9.5	13.2
0605	Drayton Harbor	Nearshore	D	621.2	150.9	495.2
			PT	8,000	1,900	6,300
			BOI	110	28	75
			BOI/km^2	8.5	2.2	5.8
0606	Boundary Bay	Nearshore	D	705.8	270.0	438.3
			PT	53,000	20,000	33,000
			BOI	780	360	480
			BOI/km^2	10.4	4.8	6.4
		Offshore	D	282.5	38.4	235.5
			PT	23,000	3,200	19,000
			BOI	430	55	460
			BOI/km^2	5.3	0.7	5.7
		Sum	D	484.1	146.5	331.2
			PT	76,000	23,000	52,000
			BOI	1,200	410	940
			BOI/km^2	7.6	2.6	6.0

TABLE H-6 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0607	San Juan Islands--Northern Tier	Nearshore	D	378.2	72.6	309.4
			PT	1,900	360	1,500
			BOI	29	8.7	27
			BOI/km^2	5.9	1.7	5.3
		Offshore	D	304.2		46.7
			PT	9,000		1,400
			BOI	140		20
			BOI/km^2	4.7		0.7
		Sum	D	319.8		84.3
			PT	11,000		2,900
			BOI	170		46
			BOI/km^2	4.9		1.3
0608	Georgia Strait	Offshore	D	158.3	11.8	81.2
			PT	46,000	3,400	23,000
			BOI	820	68	590
			BOI/km^2	2.8	0.2	2.1
		Region total	D	344.6	67.8	178.5
			PT	193,000	38,000	100,000
			BOI	3,100	680	2,000
			BOI/km^2	5.5	1.2	3.6

TABLE H-7. GEORGIA STRAIT--WESTERN REGION (07--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0701	Pt. Roberts	Nearshore	D	402.4	123.8	204.7
			PT	6,600	2,000	3,300
			BOI	140	45	54
			BOI/km^2	8.9	2.8	3.3
0702	Tsawwassen Bay	Nearshore	D	361.8	65.4	199.0
			PT	2,200	400	1,200
			BOI	47	7.4	22
			BOI/km^2	28.5	4.5	13.5
0703	Georgia Strait	Offshore	D	13.2	0.9	2.2
			PT	4,800	330	810
			BOI	110	6.2	14
			BOI/km^2	0.66	<0.1	<0.1
		Region total	D	72.4	12.1	23.3
			PT	28,000	4,700	9,000
			BOI	560	91	160
			BOI/km^2	1.4	0.2	0.4

TABLE H-8. HARO STRAIT REGION (08--), SUMMARIES OF SUBREGION, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0801	Northern Haro Strait	Nearshore	D	375.0	172.4	675.4
			PT	3,600	1,700	6,500
			BOI	64	41	110
			BOI/km^2	6.6	4.2	11.3
		Offshore	D	7.6	3.3	42.9
			PT	2,500	1,100	14,000
			BOI	46	21	330
			BOI/km^2	0.1	<0.1	1.0
		Sum	D	18.0	8.3	62.0
			PT	6,100	2,800	21,000
			BOI	110	62	440
			BOI/km^2	0.3	0.2	1.3
0802	Southern Haro Strait	Nearshore	D	12.0	4.2	129.6
			PT	60	21	650
			BOI	1.1	0.43	8.0
			BOI/km^2	0.2	<0.1	1.6
		Offshore	D	4.5	2.1	4.8
			PT	990	460	1,000
			BOI	19	8.2	20
			BOI/km^2	0.1	<0.1	0.1
		Sum	D	4.4	2.1	7.6
			PT	1,000	480	1,700
			BOI	21	8.6	28
			BOI/km^2	0.1	<0.1	0.1

TABLE H-8 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
		Region total	D	12.8	5.7	39.0
			PT	7,200	3,200	22,000
			BOI	130	70.6	460
			BOI/km^2	0.2	0.1	0.8

TABLE H-9. ROSARIO STRAIT REGION (09--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0901	Southern Rosario Strait	Nearshore	D	144.0	189.3	64.7
			PT	1,600	2,100	700
			BOI	32	40	14
			BOI/km^2	3.0	3.7	1.3
		Offshore	D	5.2	3.3	19.0
			PT	590	370	2,100
			BOI	13	12	55
			BOI/km^2	0.1	0.1	0.5
		Sum	D	17.0	19.5	22.7
			PT	2,100	2,400	2,800
			BOI	45	52	69
			BOI/km^2	0.4	0.4	0.6
0902	Central Rosario Strait	Nearshore	D	261.3	199.8	485.0
			PT	1,000	740	1,800
			BOI	18	15	25
			BOI/km^2	4.9	3.9	6.7
		Offshore	D	8.8	0.3	60.0
			PT	700	25	4,800
			BOI	18	0.47	120
			BOI/km^2	0.2	<0.1	1.5
		Sum	D	20.5	9.1	79.4
			PT	1,700	760	6,600
			BOI	36	15	140
			BOI/km^2	0.3	0.1	1.1

TABLE H-9 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
0903	Northern Rosario Strait	Nearshore	D	166.8	145.0	91.7
			PT	550	480	300
			BOI	10	9.1	7.1
			BOI/km^2	3.0	2.7	2.1
		Offshore	D	96.0	9.4	31.3
			PT	8,500	830	2,800
			BOI	150	18	71
			BOI/km^2	6.0	4.0	0.8
		Sum	D	98.7	14.1	33.6
			PT	9,100	1,300	3,100
			BOI	160	27	78
			BOI/km^2	1.7	0.3	0.8
		Region total	D	43.6	15.1	40.2
			PT	13,000	4,500	12,000
			BOI	240	94	290
			BOI/km^2	0.8	0.3	1.0

TABLE H-10. SAN JUAN ISLANDS--NORTHERN WATERS REGION (10--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1001	President Channel	Nearshore	D	257.8	369.2	241.3
			PT	820	1,200	770
			BOI	15	23	13
			BOI/km^2	4.8	4.9	4.1
		Offshore	D	4.4	2.0	46.6
			PT	440	200	4,700
			BOI	8.6	3.4	140
			BOI/km^2	0.1	<0.1	1.4
		Sum	D	12.5	13.5	52.1
			PT	1,300	1,400	5,400
			BOI	24	26	150
			BOI/km^2	0.2	0.3	1.4
1002	Northern Areas	Nearshore	D	37.1	15.9	152.2
			PT	74	32	300
			BOI	1.7	0.71	6.5
			BOI/km^2	0.8	0.4	3.3
		Offshore	D	10.0	5.0	103.5
			PT	480	240	5,000
			BOI	8.7	4.5	94
			BOI/km^2	0.2	0.1	2.0

TABLE H-10 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1002	Northern Areas	Sum	D	11.0	5.4	106.0
			PT	550	270	5,300
			BOI	10	5.2	100
			BOI/km^2	0.2	0.1	2.0
		Region total	D	12.4	8.5	71.6
			PT	1,900	1,300	11,000
			BOI	35	24.2	250
			BOI/km^2	0.2	0.2	1.6

TABLE H-11. SAN JUAN ISLANDS--INTERIOR CHANNELS AND PASSAGES REGION (11--), SUMMARIES OF SUBREGION, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1101	Speiden Channel	Nearshore	D	96.7	10.0	77.5
			PT	110	11	85
			BOI	2.3	0.32	1.3
			BOI/km^2	2.1	0.3	1.2
		Offshore	D	8.0	4.5	56.7
			PT	100	57	710
			BOI	2.4	1.4	8.1
			BOI/km^2	0.2	0.1	0.6
		Sum	D	15.3	5.0	58.4
			PT	210	68	800
			BOI	4.7	1.7	9.4
			BOI/km^2	0.3	0.1	0.7
1102	Northern San Juan Channel	Nearshore	D	5.3	1.9	27.9
			PT	15	6	81
			BOI	0.30	0.10	1.5
			BOI/km^2	0.1	<0.1	0.5
		Offshore	D	7.0	1.2	6.2
			PT	230	38	210
			BOI	3.7	0.83	3.8
			BOI/km^2	0.1	<0.1	0.1
		Sum	D	6.8	1.2	8.0
			PT	250	44	290
			BOI	4.0	0.93	5.3
			BOI/km^2	0.1	<0.1	0.1

TABLE H-11 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1103	Southern San Juan Channel	Nearshore	D	65.4	143.5	249.2
			PT	330	720	1,200
			BOI	6.6	15	19
			BOI/km^2	1.3	2.9	3.8
		Offshore	D	10.8	46.2	78.9
			PT	470	2,000	3,400
			BOI	12	39	79
			BOI/km^2	0.3	0.9	1.8
		Sum	D	16.5	55.7	96.9
			PT	800	2,700	4,700
			BOI	18	53	98
			BOI/km^2	0.4	1.1	2.0
1104	Wasp Pass	Nearshore	D	18.7	8.4	30.4
			PT	47	21	76
			BOI	1.0	0.50	1.1
			BOI/km^2	0.4	0.2	0.4
1105	Upright Channel	Nearshore	D	4.2	*	28.0
			PT	37		250
			BOI	0.85		6.3
			BOI/km^2	0.1		0.7
1106	Harney Channel	Nearshore	D	7.0	1.3	16.7
			PT	15	3	37
			BOI	0.34	0.08	0.57
			BOI/km^2	0.2	<0.1	0.3

TABLE H-11 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1106	Harney Channel	Offshore	D	12.2	1.8	13.4
			PT	380	55	410
			BOI	9.9	1.6	9.4
			BOI/km^2	0.3	<0.1	0.3
		Sum	D	11.0	1.6	13.7
			PT	390	58	450
			BOI	10	1.6	9.9
			BOI/km^2	0.3	<0.1	0.3
1107	Obstruction Pass	Nearshore	D	31.7	15.8	529.8
			PT	79	40	1,300
			BOI	2.0	0.85	36
			BOI/km^2	0.8	0.3	14.3
1108	Thatcher Pass	Nearshore	D	12.8	3.3	22.9
			PT	67	17	120
			BOI	1.4	0.40	1.6
			BOI/km^2	0.3	<0.1	0.3
		Region total	D	12.3	20.6	54.1
			PT	1,800	3,000	7,900
			BOI	41	59	170
			BOI/km^2	0.3	0.4	1.2

*No data are available.

TABLE H-12. SAN JUAN ISLANDS--INTERIOR BAYS REGION (12--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1201	Mosquito/Roche Complex	Nearshore	D	218.7	52.6	66.9
			PT	2,200	540	680
			BOI	40	10	11
			BOI/km^2	6.6	1.7	1.8
1202	Friday Harbor	Nearshore	D	53.2	23.4	72.0
			PT	80	35	110
			BOI	1.5	0.66	2.2
			BOI/km^2	1.0	0.4	1.4
1203	Griffin Bay	Nearshore	D	313.2	116.2	269.0
			PT	2,300	870	2,000
			BOI	6.3	16.8	35
			BOI/km^2	0.83	2.2	4.6
		Offshore	D	43.6	2.7	62.7
			PT	330	20	470
			BOI	10	0.87	16
			BOI/km^2	1.3	0.1	2.1
		Sum	D	173.3	59.3	166.7
			PT	2,600	890	2,500
			BOI	16	17.7	51
			BOI/km^2	1.1	1.2	3.4
1205	Fisherman Bay	Nearshore	D	264.7	83.3	223.3
			PT	500	160	420
			BOI	6.6	2.9	5.1
			BOI/km^2	3.5	1.5	2.7

TABLE H-12 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1206	Swift's/Shoal Bays	Nearshore	D	104.8	18.1	110.9
			PT	480	83	510
			BOI	11	1.8	9.9
			BOI/km^2	2.5	0.4	2.2
1207	Deer Harbor	Nearshore	D	32.0	17.5	81.0
			PT	64	35	160
			BOI	1.3	0.74	3.5
			BOI/km^2	0.6	0.4	1.8
1208	West Sound	Nearshore	D	16.5	5.6	132.6
			PT	150	51	1,200
			BOI	3.1	0.87	34
			BOI/km^2	0.3	0.1	3.7
1209	East Sound	Nearshore	D	59.0	7.7	55.3
			PT	180	24	170
			BOI	3.8	0.44	4.3
			BOI/km^2	1.2	0.1	1.4
		Offshore	D		0.9	5.4
			PT		24	140
			BOI		0.45	3.2
			BOI/km^2		<0.1	0.1
		Sum	D		1.6	10.5
			PT		48	310
			BOI		0.89	7.5
			BOI/km^2		<0.1	0.3

TABLE H-12 (continued).

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1210	Lopez Sound	Nearshore	D	75.4	27.5	145.1
			PT	1,800	660	3,500
			BOI	40	13	85
			BOI/km^2	1.7	0.6	3.6
		Region total	D	79.2	24.4	91.9
			PT	8,100	2,500	9,400
			BOI	120	43	210
			BOI/km^2	1.2	0.5	2.1

TABLE H-13. CANADIAN WATERS REGION (13--), SUMMARIES OF SUBREGIONS, 1979

Subregion				Season		
Code	Name	Area		Spring	Summer	Fall
1301	Active Pass	Nearshore	D	348.5	15.6	107.3
			PT	3,700	160	1,100
			BOI	62	3.0	14
			BOI/km^2	5.9	0.3	1.3
1302	Canadian Gulf Islands	Offshore	D	18.1	1.0	6.4
			PT	2,600	150	920
			BOI	29	2.7	16
			BOI/km^2	0.2	<0.1	0.1
1303	Sidney Approach	Offshore	D	27.8	3.6	32.3
			PT	3,300	430	3,800
			BOI	81	12	78
			BOI/km^2	0.7	0.1	0.7
		Region total	D	88.1	4.5	33.2
			PT	9,500	740	5,800
			BOI	170	18	110
			BOI/km^2	6.8	0.4	2.1

APPENDIX I

REGIONAL AND SUBREGIONAL SUMMARIES, 1978 AND 1979, COMBINED

Seasonal monthly groupings for 1978 and 1979 combined are as follows: Spring--April and May; Summer--June; Fall--July, August, September, and October; and Winter--January, February, March, November, and December.

TABLE I-1. SWIFTSURE BANK REGION (01--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0101	Swiftsure Bank	Region total	D	*	*	165.3	*
			PT			14,000	
			BOI			1,700	
			BOI/km^2			2.0	

TABLE I-2. STRAIT OF JUAN DE FUCA--OUTER REGION (02--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0201	Strait of Juan de Fuca--Outer	Offshore	D	3.5	1.2	71.5	19.6
			PT	6,600	2,400	130,000	37,000
			BOI	170	56	3,900	1,000
			BOI/km^2	0.1	<0.1	2.1	0.5
0202	Vancouver Island	Nearshore	D	85.6	*	255.2	80.9
			PT	4,400		13,000	4,200
			BOI	90		230	83
			BOI/km^2	1.7		4.6	1.6
0203	Cape Flattery	Nearshore	D	916.0	60.9	1,471.0	488.8
			PT	4,900	330	7,900	2,600
			BOI	95	7	150	50
			BOI/km^2	17.7	1.3	27.3	9.3
0204	Neah Bay	Nearshore	D	103.9	43.4	483.0	154.0
			PT	470	200	2,200	690
			BOI	7.4	3.3	31	12
			BOI/km^2	1.6	0.7	6.8	2.6
0205	Neah Bay to Clallam Bay	Nearshore	D	128.9	140.3	575.0	210.6
			PT	1,700	1,800	7,400	2,700
			BOI	32	36	120	48
			BOI/km^2	2.5	2.8	9.3	3.7
0206	Clallam Bay	Nearshore	D	60.5	45.3	222.0	84.1
			PT	190	140	710	270
			BOI	3.7	3.3	10	5.3
			BOI/km^2	1.1	1.0	3.0	1.7

TABLE I-2 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0207	Clallam Bay to Crescent Bay	Nearshore	D	134.2	37.4	392.2	225.7
			PT	2,800	780	8,200	4,700
			BOI	63	15	110	71
			BOI/km^2	3.0	0.7	5.2	3.4
0208	Crescent Bay	Nearshore	D	178.1	41.7	321.1	238.8
			PT	200	46	350	260
			BOI	4.0	1.1	4.9	4.8
			BOI/km^2	3.6	1.0	4.4	4.4
0209	Crescent Bay to Ediz Hook	Nearshore	D	442.0	57.7	509.2	861.1
			PT	4,000	520	4,600	7,800
			BOI	60	12	74	130
			BOI/km^2	6.7	1.4	8.2	14.5
		Region total	D	12.5	3.1	90.4	30.1
			PT	25,000	6,200	180,000	60,000
			BOI	530	130	4,600	1,400
			BOI/km^2	0.3	0.1	2.3	0.7

*No data are available.

TABLE I-3. STRAIT OF JUAN DE FUCA--INNER REGION (03--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0301	Strait of Juan de Fuca--Inner	Offshore	D	11.1	10.5	42.0	22.1
			PT	18,000	17,000	69,000	36,000
			BOI	490	420	1,700	750
			BOI/km^2	0.3	0.3	1.0	0.5
0302	Ediz Hook	Nearshore	D	31.4	31.7	140.3	38.0
			PT	13	13	56	15
			BOI	0.29	0.33	1.3	0.27
			BOI/km^2	0.7	0.8	3.3	0.7
0303	Port Angeles	Nearshore	D	68.6	34.0	267.8	203.8
			PT	710	350	2,800	2,100
			BOI	15	7.3	39	39
			BOI/km^2	1.5	0.7	3.8	3.7
0304	Voice of America	Nearshore	D	98.9	134.8	205.9	130.3
			PT	2,400	3,200	4,900	3,100
			BOI	58	75	95	50
			BOI/km^2	2.4	3.1	4.0	2.1
0305	Dungeness Spit	Nearshore	D	158.1	277.0	939.3	747.3
			PT	630	1,100	3,800	3,000
			BOI	14	22	55	32
			BOI/km^2	3.5	5.4	13.7	7.9
0306	Dungeness Bay/ Harbor	Nearshore	D	539.1	179.1	518.8	575.1
			PT	6,500	2,100	6,200	6,900
			BOI	130	35	78	78
			BOI/km^2	10.5	2.9	6.5	6.5

TABLE I-3 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0307	Jamestown	Nearshore	D	720.5	525.9	1,305.8	1,164.5
			PT	15,000	11,000	28,000	25,000
			BOI	330	200	270	320
			BOI/km^2	15.2	9.3	12.8	14.7
0308	Sequim Bay	Nearshore	D	206.1	2.9	215.5	285.8
			PT	2,400	34	2,540	3,400
			BOI	37	0.83	41	46
			BOI/km^2	3.2	<0.1	3.4	3.9
		Offshore	D	130.0	1.7	266.7	236.1
			PT	260	3	530	470
			BOI	6.0	0.06	14	7.5
			BOI/km^2	3.0	<0.1	7.1	3.7
		Sum	D	202.9	2.7	224.6	275.4
			PT	2,800	37	3,100	3,800
			BOI	44	0.90	55	54
			BOI/km^2	3.2	0.1	4.0	3.9
0309	Miller Peninsula	Nearshore	D	120.1	290.0	170.7	454.2
			PT	580	1,400	820	2,200
			BOI	13	31	14	39
			BOI/km^2	2.7	6.4	2.8	8.1
0310	Protection Island	Nearshore	D	1,452.2	2,680.0	1,857.5	1,189.6
			PT	4,500	8,300	5,800	3,700
			BOI	120	170	120	64
			BOI/km^2	39.0	53.5	37.8	20.7

TABLE I-3 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0311	Discovery Bay	Nearshore	D	173.3	13.4	93.2	401.8
			PT	2,300	170	1,200	5,200
			BOI	50	3.8	23	96
			BOI/km^2	3.8	0.3	1.8	7.4
		Offshore	D	62.4	8.0	79.7	212.8
			PT	1,500	190	1,900	5,100
			BOI	40	3.7	53	130
			BOI/km^2	1.7	0.2	2.2	5.6
		Sum	D	109.2	10.6	89.1	287.4
			PT	3,800	370	3,100	10,000
			BOI	90	7.5	76	230
			BOI/km^2	2.6	0.2	2.2	6.6
0312	Quimper Peninsula	Nearshore	D	199.7	340.8	709.2	640.6
			PT	2,100	3,600	7,600	6,900
			BOI	38	81	110	110
			BOI/km^2	3.6	7.6	10.3	10.3
0313	Whidbey Island	Nearshore	D	27.2	26.0	203.7	126.2
			PT	570	550	4,300	2,700
			BOI	11	15	92	45
			BOI/km^2	0.5	0.7	4.4	2.2
0314	Smith Island	Nearshore	D	1,285.6	2,643.3	3,400.0	4,858.0
			PT	390	1,000	1,000	1,500
			BOI	8.8	16	18	14
			BOI/km^2	29.3	54.4	60.0	45.5

TABLE I-3 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0315	Deception Pass	Nearshore	D	49.4	45.0	145.9	106.9
			PT	280	250	820	600
			BOI	6.7	7.3	17	13
			BOI/km^2	1.2	1.3	3.1	2.4
0316	Lopez Island (south shore)	Nearshore	D	724.9	529.9	841.6	431.0
			PT	6,500	4,800	7,500	3,800
			BOI	130	95	150	76
			BOI/km^2	14.4	10.7	16.6	8.5
0317	San Juan Island (south shore)	Nearshore	D	192.8	48.2	514.6	353.0
			PT	670	170	1,800	1,200
			BOI	8.6	3.0	32	15
			BOI/km^2	2.5	0.9	9.2	4.2
0318	Victoria, Vancouver Island	Nearshore	D	*	*	*	1,110.0
			PT				7,700
			BOI				140
			BOI/km^2				20.4
		Region total	D	35.7	30.8	82.5	66.0
			PT	65,000	56,000	150,000	120,000
			BOI	5,200	1,200	2,900	2,100
			BOI/km^2	2.9	0.7	1.6	1.2

*No data are available.

TABLE I-4. ADMIRALTY INLET REGION (04--), SUMMARIES OF SUBREGIONS, 1979 DATA ONLY*

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0401	Admiralty Inlet	Region total	D	65.9	100.7	84.6	57.7
			PT	4,900	7,600	6,300	4,300
			BOI	160	330	190	97
			BOI/km^2	2.2	4.4	2.6	1.3

*Based on census transects used in 1978 supplemented with data from Edmonds-Port Townsend ferry in 1979.

TABLE I-5. ANACORTES TO HALES PASSAGE REGION (05--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0501	Bellingham Channel	Nearshore	D	201.3	124.9	345.3	344.2
			PT	950	590	1,600	1,600
			BOI	18	12	29	25
			BOI/km^2	3.7	2.6	6.2	5.3
		Offshore	D	39.7	15.6	151.7	135.6
			PT	2,700	1,100	10,000	9,400
			BOI	62	25	300	220
			BOI/km^2	0.9	0.4	4.3	3.1
		Sum	D	50.1	23.0	162.4	148.8
			PT	3,700	1,700	12,000	11,000
			BOI	79	37	320	240
			BOI/km^2	1.1	0.5	4.5	3.2
0502	Guemes Channel	Nearshore	D	61.0	27.9	28.3	160.4
			PT	620	280	290	1,600
			BOI	17	10	3.7	42
			BOI/km^2	1.6	1.0	0.4	4.1
0503	Fidalgo Bay	Nearshore	D	145.0	29.7	103.3	391.1
			PT	1,700	340	1,200	4,500
			BOI	38	6.0	16	61
			BOI/km^2	3.3	0.5	1.4	5.3
0504	Padilla Bay	Nearshore	D	369.1	50.5	165.5	414.1
			PT	20,000	2,800	9,100	23,000
			BOI	470	50	110	370
			BOI/km^2	8.5	0.9	2.0	6.7

TABLE I-5 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0504	Padilla Bay	Offshore	D	1,050.5	83.9	649.6	2,424.9
			PT	26,000	2,100	16,000	61,000
			BOI	570	39	270	1,200
			BOI/km^2	22.9	1.5	10.8	48.0
		Sum	D	575.0	61.3	312.5	1,050.0
			PT	46,000	4,900	25,000	84,000
			BOI	1,000	89	380	1,600
			BOI/km^2	12.5	1.1	4.8	20.0
0505	Samish Bay	Nearshore	D	342.6	53.1	273.7	745.8
			PT	9,900	1,500	7,900	22,000
			BOI	290	25	110	280
			BOI/km^2	10.0	0.9	3.8	4.6
		Offshore	D	667.9	23.0	182.7	783.8
			PT	25,000	850	6,800	29,000
			BOI	570	17	180	430
			BOI/km^2	22.8	0.7	6.2	17.2
		Sum	D	530.3	36.4	227.3	772.7
			PT	35,000	2,400	15,000	51,000
			BOI	860	42	290	710
			BOI/km^2	13.0	0.6	4.4	10.8
0506	Bellingham Bay	Nearshore	D	113.3	65.1	78.7	243.0
			PT	4,100	2,300	2,800	8,700
			BOI	81	47	53	190
			BOI/km^2	2.2	1.3	1.5	5.3

TABLE I-5 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0506	Bellingham Bay	Offshore	D	121.2	16.6	73.9	258.7
			PT	15,000	2,000	9,000	32,000
			BOI	390	37	250	860
			BOI/km^2	3.2	0.3	2.0	7.0
		Sum	D	120.3	27.8	75.9	259.5
			PT	19,000	4,400	12,000	41,000
			BOI	470	83	300	1,000
			BOI/km^2	3.0	0.5	1.9	6.3
0507	Hales Passage	Nearshore	D	182.9	38.5	35.6	77.8
			PT	2,900	620	570	1,300
			BOI	58	21	13	25
			BOI/km^2	3.6	1.3	0.8	1.6
		Region total	D	264.6	36.1	158.8	457.1
			PT	110,000	15,000	66,000	190,000
			BOI	2,500	290	1,300	3,700
			BOI/km^2	6.0	0.7	3.1	8.9

TABLE I-6. GEORGIA STRAIT--EASTERN REGION (06--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0601	Lummi Bay	Nearshore	D	1,578.8	54.9	357.8	731.7
			PT	27,000	930	6,100	12,000
			BOI	350	15	68	120
			BOI/km^2	20.6	0.9	4.0	7.1
		Offshore	D	576.3	45.6	151.3	529.6
			PT	4,600	360	1,200	4,200
			BOI	96	6.5	25	110
			BOI/km^2	12.0	0.8	3.1	13.7
		Sum	D	1,280.0	52.0	292.0	680.0
			PT	32,000	1,300	7,300	17,000
			BOI	450	22	93	220
			BOI/km^2	18.0	0.9	3.7	8.8
0602	Cherry Point	Nearshore	D	1,370.1	38.8	38.5	126.9
			PT	19,000	550	540	1,800
			BOI	460	12	11	34
			BOI/km^2	32.5	0.9	0.8	2.4
0603	Birch Bay	Nearshore	D	784.2	73.8	535.0	411.3
			PT	7,100	660	4,800	3,700
			BOI	140	11	77	55
			BOI/km^2	15.6	1.2	8.6	6.1
		Offshore	D	149.0	30.0	91.3	217.7
			PT	1,500	300	910	2,200
			BOI	32	4.4	23	47
			BOI/km^2	3.2	0.4	2.3	4.7

TABLE I-6 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0603	Birch Bay	Sum	D	452.6	50.5	300.0	310.5
			PT	8,600	960	5,700	5,900
			BOI	170	15	100	100
			BOI/km^2	8.9	0.8	5.3	5.3
0604	Semiahmoo	Nearshore	D	984.5	435.8	671.6	1,159.0
			PT	9,400	4,100	6,400	11,000
			BOI	190	74	160	180
			BOI/km^2	20.2	7.8	16.4	18.6
0605	Drayton Harbor	Nearshore	D	540.6	137.7	506.2	877.1
			PT	6,900	1,800	6,500	11,000
			BOI	96	26	74	130
			BOI/km^2	7.5	2.0	5.8	9.9
0606	Boundary Bay	Nearshore	D	706.7	270.0	438.3	306.7
			PT	53,000	20,000	33,000	23,000
			BOI	780	360	480	380
			BOI/km^2	10.4	4.8	6.4	5.1
		Offshore	D	221.8	39.5	165.0	702.2
			PT	18,000	3,200	14,000	58,000
			BOI	340	56	330	1,400
			BOI/km^2	4.2	0.7	4.0	16.7
		Sum	D	452.2	146.5	293.0	515.9
			PT	71,000	23,000	46,000	81,000
			BOI	1,100	410	810	1,800
			BOI/km^2	7.0	2.6	5.2	11.5

TABLE I-6 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0607	San Juan Islands--Northern Tier	Nearshore	D	281.2	74.8	362.0	233.4
			PT	1,400	370	1,800	1,200
			BOI	22	8.9	32	23
			BOI/km^2	4.4	1.8	6.3	4.5
		Offshore	D	223.8	1.0	35.6	259.2
			PT	6,600	29	1,000	7,600
			BOI	100	0.56	24	170
			BOI/km^2	3.5	<0.1	0.8	5.9
		Sum	D	232.6	11.6	84.3	255.8
			PT	8,000	400	2,900	8,800
			BOI	120	9.4	56	200
			BOI/km^2	3.5	0.3	1.6	5.8
0608	Georgia Strait	Offshore	D	130.3	11.8	61.4	76.6
			PT	38,000	3,400	18,000	22,000
			BOI	680	68	510	540
			BOI/km^2	2.4	0.2	1.4	1.9
		Region total	D	339.2	64.3	167.8	285.7
			PT	190,000	36,000	94,000	160,000
			BOI	3,300	640	1,800	3,200
			BOI/km^2	5.9	1.1	3.2	5.7

TABLE I-7. GEORGIA STRAIT--WESTERN REGION (07--), SUMMARIES OF SUBREGION, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0701	Pt. Roberts	Nearshore	D	461.4	100.7	163.2	518.4
			PT	7,500	1,600	2,700	8,400
			BOI	170	37	44	160
			BOI/km^2	10.3	2.2	2.7	9.6
0702	Tsawwassen Bay	Nearshore	D	1,069.3	64.3	238.7	868.9
			PT	6,500	390	1,500	5,300
			BOI	130	7.4	25	56
			BOI/km^2	21.3	1.2	4.1	9.2
0703	Georgia Strait	Offshore	D	9.2	2.7	2.5	3.5
			PT	3,400	970	910	1,300
			BOI	82	15	15	32
			BOI/km^2	0.2	<0.1	<0.1	0.1
		Region total	D	43.9	7.8	13.2	38.8
			PT	17,000	3,000	5,100	15,000
			BOI	380	59	84	250
			BOI/km^2	1.0	0.1	0.2	0.6

TABLE I-8. HARO STRAIT REGION (08--), SUMMARIES OF SUBREGION, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0801	Northern Haro Strait	Nearshore	D	212.2	274.2	465.8	312.4
			PT	2,000	2,600	4,500	3,000
			BOI	37	61	76	47
			BOI/km^2	3.8	6.3	7.9	4.9
		Offshore	D	6.7	5.0	38.9	19.8
			PT	2,200	1,600	13,000	6,500
			BOI	41	36	290	130
			BOI/km^2	0.1	0.1	0.9	0.4
		Sum	D	12.4	12.7	53.1	28.0
			PT	4,200	4,300	18,000	9,500
			BOI	78	97	370	180
			BOI/km^2	0.2	0.3	1.1	0.5
0802	Southern Haro Strait	Nearshore	D	34.2	4.2	198.4	95.9
			PT	170	21	990	480
			BOI	2.6	0.43	14	7.8
			BOI/km^2	0.5	<0.1	2.9	1.6
		Offshore	D	4.7	1.7	4.6	9.9
			PT	1,000	380	1,000	2,200
			BOI	21	7.9	21	49
			BOI/km^2	0.1	<0.1	0.1	0.2
		Sum	D	5.3	1.8	8.9	12.0
			PT	1,200	400	2,000	2,700
			BOI	24	8.3	35	57
			BOI/km^2	0.1	<0.1	0.2	0.3

TABLE I-8 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0802	Southern Haro Strait	Region total	D	9.6	8.3	35.4	21.2
			PT	5,400	4,700	20,000	12,000
			BOI	100	110	410	240
			BOI/km^2	0.2	0.2	0.7	0.4

TABLE I-9. ROSARIO STRAIT REGION (09--), SUMMARIES OF SUBREGIONS 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0901	Southern Rosario Strait	Nearshore	D	109.0	167.8	138.0	264.0
			PT	1,200	1,800	1,500	2,900
			BOI	24	38	32	72
			BOI/km^2	2.2	3.5	3.0	6.6
		Offshore	D	6.2	3.2	35.6	84.8
			PT	700	360	4,000	9,500
			BOI	15	9.4	93	250
			BOI/km^2	0.1	<0.1	0.8	2.2
		Sum	D	15.4	17.9	44.6	97.4
			PT	1,900	2,200	5,500	12,000
			BOI	39	47	120	320
			BOI/km^2	0.3	0.4	1.0	2.6
0902	Central Rosario Strait	Nearshore	D	174.8	199.8	533.9	299.8
			PT	650	740	2,000	1,100
			BOI	12	15	30	16
			BOI/km^2	3.2	3.9	8.0	4.4
		Offshore	D	10.1	0.3	92.7	64.7
			PT	800	25	7,400	5,100
			BOI	20	0.47	190	120
			BOI/km^2	0.3	<0.1	2.4	1.6
		Sum	D	18.1	9.1	113.1	74.6
			PT	1,500	760	9,400	6,200
			BOI	32	15	220	140
			BOI/km^2	0.4	0.2	2.6	1.7

TABLE I-9 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
0903	Northern Rosario Strait	Nearshore	D	352.7	135.9	203.6	218.8
			PT	1,100	450	670	720
			BOI	20	8.9	11	12
			BOI/km^2	6.1	2.7	3.3	3.7
		Offshore	D	266.0	75.4	86.1	36.9
			PT	24,000	6,700	7,600	3,300
			BOI	310	130	200	87
			BOI/km^2	3.5	1.5	2.2	1.0
		Sum	D	271.1	78.1	90.0	43.4
			PT	25,000	7,200	8,300	4,000
			BOI	330	140	210	99
			BOI/km^2	3.6	1.5	2.3	1.1
		Region total	D	93.8	33.5	77.1	73.7
			PT	28,000	10,000	23,000	22,000
			BOI	400	200	550	560
			BOI/km^2	1.3	0.7	1.8	1.8

TABLE I-10. SAN JUAN ISLANDS--NORTHERN WATERS REGION (10--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1001	President Channel	Nearshore	D	182.4	245.4	220.4	253.0
			PT	580	790	710	810
			BOI	11	15.6	12	14
			BOI/km^2	3.5	4.9	3.7	4.4
		Offshore	D	7.6	2.0	29.7	37.9
			PT	760	200	3,000	3,800
			BOI	16	3.4	80	81
			BOI/km	0.2	<0.1	0.8	0.8
		Sum	D	12.5	9.6	35.7	44.4
			PT	1,300	990	3,700	4,600
			BOI	27	19	92	95
			BOI/km^2	0.3	0.2	0.9	0.9
1002	Northern Areas	Nearshore	D	22.7	15.9	141.5	69.4
			PT	45	32	280	140
			BOI	0.97	0.71	4.0	2.8
			BOI/km^2	0.5	0.4	2.0	1.4
		Offshore	D	31.9	5.0	74.6	168.4
			PT	1,500	240	3,600	8,100
			BOI	24	4.5	65	170
			BOI/km^2	0.5	<0.1	1.3	2.2

TABLE I-10 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1002	Northern Areas	Sum	D	32.0	5.4	78.0	164.0
			PT	1,600	270	3,900	8,200
			BOI	25	5.2	70	170
			BOI/km^2	0.5	0.1	1.4	3.4
		Region total	D	18.9	8.5	48.8	83.3
			PT	2,900	1,300	7,500	12,800
			BOI	52	24	160	270
			BOI/km^2	0.3	0.2	1.0	1.8

TABLE I-11. SAN JUAN ISLANDS--INTERIOR CHANNELS AND PASSAGES REGION (11--), SUMMARIES OF SUBREGION 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1101	Speiden Channel	Nearshore	D	74.6	10.0	318.3	251.2
			PT	82	11	350	280
			BOI	1.8	0.32	5.5	5.6
			BOI/km^2	1.7	0.3	5.0	5.1
		Offshore	D	8.4	3.1	70.2	76.4
			PT	110	39	890	960
			BOI	2.9	0.91	9.8	17
			BOI/km^2	0.2	<0.1	0.8	1.4
		Sum	D	13.9	3.6	87.6	87.6
			PT	190	50	1,200	1,200
			BOI	4.7	1.2	15	23
			BOI/km^2	0.3	0.1	1.1	1.7
1102	Northern San Juan Channel	Nearshore	D	5.3	1.9	21.5	28.6
			PT	15	6	62	83
			BOI	0.30	0.10	1.0	1.2
			BOI/km^2	0.1	<0.1	0.4	0.4
		Offshore	D	5.2	0.8	8.1	16.6
			PT	170	26	270	550
			BOI	3.0	0.53	4.2	14
			BOI/km^2	<0.1	<0.1	0.1	0.4

TABLE I-11 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1102	Northern San Juan Channel	Sum	D	5.2	0.8	9.1	17.5
			PT	190	31	330	630
			BOI	3.3	0.63	5.3	16
			BOI/km^2	0.1	<0.1	0.1	0.4
1103	Southern San Juan Channel	Nearshore	D	193.6	143.5	336.0	188.7
			PT	970	720	1,700	940
			BOI	19	15	29	18
			BOI/km^2	3.8	2.9	5.8	3.5
		Offshore	D	3.6	272.3	67.3	88.5
			PT	160	12,000	2,900	3,800
			BOI	3.7	340	65	100
			BOI/km^2	<0.1	7.8	1.5	2.4
		Sum	D	22.7	268.0	94.8	96.9
			PT	1,100	13,000	4,600	4,700
			BOI	23	350	94	120
			BOI/km^2	0.5	7.2	1.9	2.5
1104	Wasp Pass	Nearshore	D	21.5	8.4	29.0	70.6
			PT	54	21	72	180
			BOI	1.3	0.50	1.1	3.8
			BOI/km^2	0.5	0.2	0.4	1.5
1105	Upright Channel	Offshore	D	6.7	52.2	32.4	63.6
			PT	59	460	280	560
			BOI	1.6	12	6.2	13
			BOI/km^2	0.2	1.4	0.7	1.5

TABLE I-11 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1106	Harney Channel	Nearshore	D	8.2	1.3	17.6	37.1
			PT	18	3	39	82
			BOI	0.41	0.08	0.57	1.3
			BOI/km^2	0.2	<0.1	0.3	0.6
		Offshore	D	11.9	4.2	15.0	61.0
			PT	370	130	460	1,900
			BOI	9.2	2.9	10	46
			BOI/km^2	0.3	<0.1	0.3	1.5
		Sum	D	11.6	4.0	15.2	60.8
			PT	380	130	500	2,000
			BOI	9.6	3.0	11	48
			BOI/km^2	0.3	0.1	0.3	1.5
1107	Obstruction Pass	Nearshore	D	35.6	15.8	529.2	229.3
			PT	89	40	1,300	570
			BOI	2.1	0.85	36	11
			BOI/km^2	0.8	0.3	14.3	4.3
1108	Thatcher Pass	Nearshore	D	10.2	3.4	34.0	26.9
			PT	53	18	180	140
			BOI	1.2	0.43	2.3	3.1
			BOI/km^2	0.1	<0.1	0.3	0.3
		Region total	D	14.4	96.0	57.6	68.5
			PT	2,100	14,000	8,400	10,000
			BOI	47	370	170	230
			BOI/km^2	0.3	2.5	1.2	1.6

TABLE I-12. SAN JUAN ISLANDS--INTERIOR BAYS REGION (12--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1201	Mosquito/Roche Complex	Nearshore	D	156.9	48.9	228.4	440.0
			PT	1,600	500	2,300	4,500
			BOI	27	9.6	44	65
			BOI/km^2	4.5	1.6	7.3	10.8
1202	Friday Harbor	Nearshore	D	38.6	17.4	88.6	246.6
			PT	58	26	130	370
			BOI	1.1	0.49	2.2	5.6
			BOI/km^2	0.7	0.3	1.5	3.7
1203	Griffin Bay	Nearshore	D	115.2	115.3	269.0	696.0
			PT	870	870	2,000	5,200
			BOI	18	17	35	84
			BOI/km^2	2.4	2.3	4.7	11.2
		Offshore	D	21.8	2.7	62.7	63.1
			PT	160	20	470	470
			BOI	4.4	0.87	16	10
			BOI/km^2	0.6	0.1	2.1	1.4
		Sum	D	66.7	59.3	166.7	380.0
			PT	1,000	890	2,500	5,700
			BOI	22	18	51	94
			BOI/km^2	1.5	1.2	3.4	6.3

TABLE I-12 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1205	Fisherman Bay	Nearshore	D	264.7	83.3	223.3	705.5
			PT	500	160	420	1,300
			BOI	6.6	2.9	5.1	20
			BOI/km^2	3.5	1.5	2.7	10.7
1206	Swift's/Shoal Bay	Nearshore	D	104.8	18.1	110.9	153.6
			PT	480	83	510	710
			BOI	11	1.8	9.9	13
			BOI/km^2	2.5	0.4	2.2	2.7
1207	Deer Harbor	Nearshore	D	32.0	17.5	81.0	118.2
			PT	64	35	160	240
			BOI	1.3	0.74	3.5	4.0
			BOI/km^2	0.6	0.4	1.8	2.0
1208	West Sound	Nearshore	D	16.5	5.6	132.6	115.4
			PT	150	51	1,200	1,000
			BOI	3.1	0.87	34	19
			BOI/km^2	0.3	0.1	3.7	2.1
1209	East Sound	Nearshore	D	58.1	8.1	54.8	38.7
			PT	180	25	170	120
			BOI	3.8	0.42	4.3	2.2
			BOI/km^2	1.2	0.13	1.4	0.7
		Offshore	D		0.9	5.4	72.0
			PT		24	140	1,900
			BOI		0.45	3.2	57
			BOI/km^2		<0.1	0.1	2.1

TABLE I-12 (continued).

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1209	East Sound	Sum	D		1.7	10.5	67.6
			PT		49	310	2,000
			BOI		0.87	7.5	59
			BOI/km^2		<0.1	0.3	2.0
1210	Lopez Sound	Nearshore	D	75.4	27.5	225.2	383.2
			PT	1,800	660	5,400	9,200
			BOI	40	13	130	160
			BOI/km^2	1.7	0.6	5.2	6.6
		Region total	D	56.7	24.4	127.1	244.4
			PT	5,800	2,500	13,000	25,000
			BOI	120	48	290	440
			BOI/km^2	1.2	0.5	2.8	4.3

TABLE I-13. CANADIAN WATERS REGION (13--), SUMMARIES OF SUBREGIONS, 1978 AND 1979

Subregion				Season			
Code	Name	Area		Spring	Summer	Fall	Winter
1301	Active Pass	Nearshore	D	537.0	14.5	99.4	385.5
			PT	5,600	150	1,000	4,000
			BOI	100	2.8	14	76
			BOI/km^2	9.9	0.3	1.3	7.2
1302	Canadian Gulf Islands	Offshore	D	18.1	1.5	8.9	32.6
			PT	2,600	220	1,300	4,700
			BOI	33	4.3	23	97
			BOI/km^2	0.2	<0.1	0.2	0.7
1303	Sidney Approach	Offshore	D	23.8	29.3	29.9	86.3
			PT	2,800	3,400	3,500	10,000
			BOI	68	74	68	200
			BOi/km^2	0.6	0.6	0.6	1.7
		Region total	D	123.2	12.8	32.5	115.8
			PT	11,000	3,800	5,800	19,000
			BOI	210	81	100	380
			BOI/km^2	10.7	0.9	2.0	9.7

APPENDIX J

BIRD-OIL INDICES AND BIRD-OIL INDICES/KM^2 RATINGS OF SUBREGIONS BY SEASON

TABLE J-1. SEASONAL BIRD-OIL RATINGS FOR EACH SUBREGION, 1978/1979

Subregion		Season							
		Spring		Summer		Fall		Winter	
Code	Name	BOI	BOI/km^2	BOI	BOI/km^2	BOI	BOI/km^2	BOI	BOI/km^2
0201	Strait of Juan de Fuca--Outer	8	1	4	1	20	5	17	2
0203	Cape Flattery	5	9	2	5	7	10	3	8
0204	Neah Bay	2	5	2	3	3	7	2	6
0205	Neah Bay to Clallam Bay	3	5	3	6	6	8	3	6
0206	Clallam Bay	2	5	2	4	2	6	2	5
0207	Clallam Bay to Crescent Bay	4	6	2	3	6	7	4	6
0208	Crescent Bay	2	6	2	4	2	6	2	6
0209	Crescent Bay to Ediz Hook	4	7	2	5	4	8	7	9
0301	Strait of Juan de Fuca--Inner	12	2	12	2	18	4	15	2
0302	Ediz Hook	1	3	1	3	2	6	1	3
0303	Port Angeles	2	5	2	3	3	6	3	6
0304	Voice of America	4	5	4	6	5	6	3	5
0305	Dungeness Spit	2	6	2	7	4	9	3	8
0306	Dungeness Bay/Harbor	7	9	3	6	5	7	5	7
0307	Jamestown	11	9	9	8	10	9	11	9
0308	Sequim Bay	3	6	1	1	4	6	4	6
0309	Miller Peninsula	2	6	3	7	2	6	3	8
0310	Protection Island	6	11	8	13	6	11	4	10
0311	Discovery Bay	5	6	2	1	5	5	10	7
0312	Quimper Peninsula	3	6	5	8	6	9	6	9
0313	Whidbey Island	2	2	2	3	5	6	3	5
0314	Smith Island	2	10	2	13	2	13	2	12
0315	Deception Pass	2	5	2	5	2	6	2	5
0316	Lopez Island (south shore)	7	9	5	9	7	9	5	8
0317	San Juan Island (south shore)	5	5	2	4	3	8	2	6

TABLE J-1 (continued).

Subregion		Season							
		Spring		Summer		Fall		Winter	
Code	Name	BOI	BOI/km^2	BOI	BOI/km^2	BOI	BOI/km^2	BOI	BOI/km^2
0401[1]	Admiralty Inlet	8	5	11	6	9	6	5	5
0401	Bellingham Channel	5	5	3	2	11	6	10	6
0502	Guemes Channel	2	5	2	4	2	2	3	6
0503	Fidalgo Bay	3	6	2	2	2	5	4	7
0504	Padilla Bay	17	9	5	5	11	6	18	9
0505	Samish Bay	16	9	3	3	10	6	15	9
0506	Bellingham Bay	12	6	5	2	10	5	17	7
0507	Hales Passage	4	6	2	5	2	4	2	5
0601	Lummi Bay	12	9	2	4	5	6	10	8
0602	Cherry Point	12	11	2	4	2	4	3	5
0603	Birch Bay	8	8	2	4	5	7	5	7
0604	Semiahmoo Spit	9	10	4	8	8	9	9	9
0605	Drayton Harbor	5	7	3	5	4	7	7	8
0606	Boundary Bay	18	7	12	6	9	7	18	9
0607	San Juan Islands--Northern Tier	7	6	2	2	4	5	9	7
0608	Georgia Strait--Eastern	14	5	4	1	13	5	13	5
0701	Pt. Roberts	8	9	3	5	3	6	8	8
0702	Tsawwassen Bay	7	10	2	5	2	6	4	8
0703	Georgia Strait--Western	5	1	2	1	2	1	3	1
0801	Northern Haro Strait	5	1	5	3	11	5	9	2
0802	Southern Haro Strait	2	1	2	1	3	1	4	2

TABLE J-1 (continued).

Subregion		Season							
		Spring		Summer		Fall		Winter	
Code	Name	BOI	BOI/km^2	BOI	BOI/km^2	BOI	BOI/km^2	BOI	BOI/km^2
0901	Southern Rosario Strait	3	2	3	2	6	4	11	6
0902	Central Rosario Strait	3	2	2	1	10	6	7	5
0903	Northern Rosario Strait	11	6	7	5	10	5	9	5
1001	President Channel	3	2	2	1	5	4	5	4
1002	Northern Areas	2	2	4	1	4	5	8	6
1101	Speiden Channel	2	2	2	1	2	5	2	5
1102	Northern San Juan Channel	2	1	1	1	2	1	2	2
1103	Southern San Juan Channel	2	2	11	7	5	5	6	5
1104	Wasp Pass	2	2	1	1	2	2	2	5
1105	Upright Channel	2	1	2	5	2	3	3	5
1106	Harney Channel	2	2	2	1	2	2	3	5
1107	Obstruction Pass	2	4	1	2	3	9	2	6
1108	Thatcher Pass	2	1	1	1	2	2	2	2
1201	Mosquito/Roche Complex	3	6	2	5	3	5	4	9
1202	Friday Harbor	2	3	1	2	2	5	2	6
1203	Griffin Bay	2	5	2	5	4	6	5	7
1205	Fishermen Bay	2	6	2	5	2	6	2	9
1206	Swift's/Shoal Bays	2	5	2	2	2	5	2	6
1207	Deer Harbor	2	3	1	2	2	5	2	5
1208	West Sound	2	2	1	1	3	6	2	5
1209	East Sound	2	5	1	1	2	2	4	5
1210	Lopez Sound	3	5	2	3	7	7	8	7

[1] 1979 data only.

APPENDIX K

Analysis of Individual Species

A. Major Species

1. Loons

All four species of loons occurred in the study area, primarily as winter visitors. While populations are of concern on a continental basis, indications were that numbers are relatively stable here. Most loons spend all their nonbreeding lives on salt water and are among the most vulnerable species to oiling.

a. Common Loon. This large loon has been extirpated from much of its former breeding range due to human activities and development. Consequently, it is Blue Listed, Class I ("widespread concern"; see Section VI-J-I for explanation). It is locally common from fall through spring in marine waters in Washington, though data are insufficient for adequate historical comparison. Usually observed singly or in pairs, loon concentrations (likely coincidental with prey concentrations) were seen primarily in protected waters. Sample seasonal maximum counts (individuals) by locations are: Birch Bay 70, Dungeness Bay 103, Drayton Harbor 142, Padilla Bay 37, Hales Passage 32, Lummi Bay 22, Port Angeles 13, and Voice of America 16 (counts for large bays like Bellingham, Padilla and Samish represent samples, not complete censuses).

While the species was present all winter, numbers at Drayton Harbor show apparent peaks due to presence of migrants (Table K-1). Decreased numbers in March and May may reflect movement of birds outside Drayton Harbor to sites of herring spawn feeding activities which occur at that season on exposed shorelines at nearby Cherry Point and Semiahmoo subregions. Presence of many fish-eating divers like loons indicates high productivity for an area and should guide both land-use and shoreline planning as well as oil spill contingency plans.

b. Yellow-billed Loon. This species has the most northerly breeding range of the loons. In recent years, probably in part due to better knowledge of winter identification marks by more observers (Binford and Remsen 1974), it has been reported each winter along the West Coast of North America, as far south as Baja California (see Remsen and Binford 1975). It appears that the study area is perhaps one of the most important wintering areas south of Alaska, with almost all winter records occurring locally in the area from Padilla Bay to Point Roberts, west to Sidney, British Columbia. Individuals occurring on a wintering location one year may regularly return to the same location in following winters. Ratios of adult to immature age classes appear to be roughly equal. Locations where birds have been noted several times include Point Roberts, south Bellingham, Padilla Bay, Sidney, B.C., and Dungeness Bay. During November and December 1979 thirteen individual birds were recorded representing the largest number yet reported in any winter.

Table K-1. Monthly mean average numbers and densities of Common Loons censused at Drayton Harbor, 1979.

Month	Number of Censuses	Mean Number of Birds	Birds/km^2 Density
January	2	26	4.1
February	3	58	4.5
March	3	24	1.9
April	3	53	4.1
May	4	22	1.7
June	4	6	0.5
July	3	8	0.6
August	4	29	2.3
September	4	65	5.1
October	3	112	8.8
November	3	52	4.1
December	1	39	3.0

Eleven of these were within the study area and most of these were located during project censuses. Other additional birds were probably present. The consistent presence of this species within the study area attests to the importance of the area to marine birds.

c. Arctic Loon. This species is a common to abundant winter resident along the Pacific Coast and was locally common in winter within the study area. Individuals were seen near shore and occasionally in relatively shallow waters along the outer edge of kelp beds (as off Whidbey Island). However, it was most often found in flocks, and in relatively deep waters, especially associating with tidal convergence areas. Birds arrive in September and leave in May.

Major concentrations occurred at: Active Pass 3,600 (individuals), Speiden Channel 190, southern Rosario Strait 500, near Sidney, B.C. 300, Point Roberts 260, Northern Rosario Strait 240, Lopez Island (southshore) 350, and Mosquito Pass 220. Coincident with the herring spawn in late winter-early spring, large flocks were observed several times in 1978 and 1979 off the shoreline from Sandy Point to Point Whitehorn, Whatcom County. Maximum flock size was 1,800 in 1978, and 1,600 in 1979. The occurrence of large flocks of Arctic Loons in the study area appeared to be associated with areas of tidal convergence and with phenomena like herring spawn.

d. Red-throated Loon. This small loon winters along both American coasts. It was widespread in small numbers during the winter in the study area, and large flocks were found in several locations. Birds arrive in September and leave in April. Whereas flocks of Arctic Loons were generally found in deep, tidal convergence areas, Red-throated Loon flocks were smaller, less compact and generally found in shallower waters like bays, though flocks (or at least aggregations of individuals) were consistently observed in winter at Deception Pass and small numbers were noted in the middle of Haro Strait over water about 260 m deep. Largest numbers (individuals) recorded within census units: 650 at Drayton Harbor, 170 at Dungeness Bay, 90 at Deception Pass, 45 at Fidalgo Bay, 70 at Bellingham Bay, 96 in Hales Passage, and 50 in Lopez Sound. In addition, aerial transect samples indicated large numbers in Boundary Bay (133 maximum in census), outer Samish Bay (326), and Bellingham Bay (64).

Populations of all loons are dependent upon preservation of food webs. Their vulnerability to oiling is reflected in high BOI ratings (Appendix B). They may be locally vulnerable to fish net entanglement.

Projected populations of loons by region during winter of 1978-1979 are given in Table K-2. These are projected from mean densities for the winter season.

Table K-2. Projected total numbers of all species of loons by region, winter 1978-1979.

Region	Projected Total
Strait of Juan de Fuca-Outer	280
Strait of Juan de Fuca-Inner	980
Admiralty Inlet	50
Anacortes-Hales Passage	2,200
Georgia Strait-Eastern	4,500
Georgia Strait-Western	100
Haro Strait	1,500
Rosario Strait	1,100
San Juans-Northern Waters	490
San Juans-Interior Channels and Passages	630
San Juans-Interior Bays	260
TOTAL	12,000

2. Western Grebe

This piscivorous diving bird was the most common grebe in the study area. It is Blue Listed as a species of concern with a restricted range. It was locally abundant and its status in the study area may be relatively stable though recent population trends are unknown. Where it occurs in large numbers it often forms an important component of the avian population and may serve as an indicator species of productivity within the area. The Western Grebe was one of the first species observed to suffer from chemical contamination of inland nesting lakes (Rudd 1964), it is one of the most frequently killed species in fish nets and oil spills on the West Coast (Smail et al. 1972). Western Grebes spend virtually their entire lives in the water, except during brief incubation periods on floating nests in inland lakes and marshes. They are seldom seen flying during their extended stay on salt water wintering habitat, and when observed it is primarily just prior to spring migration. It is one of the most specialized and vulnerable species (to oil spills) in the study area (Appendix B).

Western Grebe showed some apparent preferences for offshore waters of the shallow embayments in the study area (see Table K-3). Most flocks occurred outside the 20 m depth contour, though individuals and small flocks may occur almost anywhere from fresh water lakes, tidal creeks and to 40 km off the Washington coast over the continental shelf. Several sizable flocks regularly winter in deep water passages in the San Juan Islands.

Table K-3. Projected total numbers of Western Grebes by region, winter 1978-1979.

Region	Projected Total
Strait of Juan de Fuca-Outer	350
Strait of Juan de Fuca-Inner	4,700
Admiralty Inlet	10
Anacortes-Hales Passage	38,000
Georgia Strait-Eastern	10,000
Georgia Strait-Western	350
Haro Strait	160
Rosario Strait	950
San Juans-Northern Waters	1,000
San Juans-Interior Channels and Passages	900
San Juans-Interior Bays	5,500
TOTAL	62,000

Western Grebes generally arrived in the study area in early September and most left in May. Nonbreeding flocks of 600-1,000 birds were observed in Bellingham Bay.

Projected wintering populations of Western Grebes by regions are given in Table K-3. These are conservative estimates, based on census averages. The Anacortes-Hales Passage region, with its shallow bays, had the vast majority of the study area total. Bellingham and Samish Bays, with a relatively large offshore water component, had about 50% of all Western Grebes wintering in the study area, and high vulnerability ratings of Bellingham Bay, in particular, reflect this (see Appendices D through I). Western Grebes may comprise 60% of all birds wintering on Bellingham Bay. Other locations where high counts of over 1,000 birds were observed in winter are Birch Bay, Discovery Bay, Fidalgo Bay, Padilla Bay, Samish Bay, Sequim Bay, and East Sound. Our Boundary Bay samples of up to 3,000 birds indicate high numbers there--the actual population may be several times that large. Flocks of 300-1,000 birds were observed in eight other locations: Dungeness Bay, Drayton Harbor, Deception Pass, Port Angeles, Point Roberts, Lopez Sound, Harney Channel, Whidbey shoreline, Cherry Point, Voice of America, and West Sound.

3. Cormorants

Cormorants were relatively common and sometimes locally numerous in the study area. Because of the requirement that they leave the water to dry their plumage, cormorants congregate at night on roosts which are free from predators and human disturbance (see Figure 27 for locations of some roosts). They also require daytime roosts near foraging areas. They are diving birds, often concentrated by feeding and roosting opportunities, and are among the most easily disturbed of all marine species. Since their populations are generally stressed directly by human activities and indirectly by effects on food webs and reproductive success, they rank high in vulnerability (Appendix B). The three species occurring in the study area appear to prefer different foraging habitats. Two species nested in the study area and reside here year round (Table 5, Figures 10 and 11), and the third was an important winter visitor and local nonbreeder in summer.

a. Double-crested Cormorant. This species is Blue Listed (Class I) and while Double-crested Cormorants are numerous in the subregions of the study area, this species is of concern here because of its very localized breeding distribution and high vulnerability to oil pollution (Appendix B). Double-crested Cormorants were known to nest in just six locations in the study area: five of these were adjacent to shipping routes in and along Rosario Strait and the sixth was on an abandoned concrete structure in Drayton Harbor which is immediately adjacent to planned shoreline development. The most important colony was on Mandarte Island, in Canadian waters of Haro Strait (see Table 5, Figure 11; Manuwal and Campbell 1979; and Campbell 1979), and a significant number of birds censused away from colonies in the study area were probably from the Mandarte colony.

Wintering and nonbreeding Double-crested Cormorants apparently roost at night primarily on colony sites and a few other roost islands. They performed daily commuting flights of considerable distances to foraging areas (see Figure 27). Hundreds of birds were noted passing Green Point, Anacortes, traveling from Rosario Strait roosts to the shallow bays to the east. Birds apparently from Mandarte Island were observed in late evening moving north up San Juan Channel and west through Speiden Channel. Others were observed going north up Haro Strait off Deadman Bay, San Juan Island. Birds from Mandarte regularly travel between there and Speiden Channel, crossing Haro Strait during hours of daylight. On one occasion, flocks totalling 145 birds were observed at dusk flying west from the Skagit Bay area, under the Deception Pass bridge, heading for Bird Rocks.

Preferred foraging areas appeared to be the shallower estuaries and bays within the study area. Double-crested Cormorants were often observed at river mouths, and this is the only cormorant species occurring on fresh water lakes or streams. Locations and size of noteworthy counts made during daylight hours away from night roosts are: Bellingham Bay 60, Portage Bay 93, Lummi Bay 114, Drayton Harbor 140, Fidalgo Bay 286, Padilla Bay 224, Samish Bay 103, Discovery Bay 70, Dungeness Bay 120, and Tsawwassen Bay 120. These represent counts of birds near foraging areas, and most birds were out of the water, roosting on log-booms, pilings, isolated gravel spits, or sand bars. Small groups and individuals were observed almost anywhere in the study area where roosts were available and disturbance minimal.

b. Brandt's Cormorant. The study area and adjacent Canadian waters are apparently a very important winter range for this cormorant. Brandt's Cormorants nest in very small numbers along the outer coast of Washington, Oregon, and British Columbia (Manuwal and Campbell 1979), and large numbers in California and Baja California, Mexico (Palmer 1962), but very large local winter concentrations were observed during this study and by others (Vermeer 1977). Especially important roosting sites were Whale and Mummy Rocks, where 2,300 birds were observed in mid-day in winter 1979. Brandt's Cormorants also probably roost at night in winter on almost all other islands used by cormorants.

This cormorant was most often observed foraging in flocks, in deeper waters than the other two species, and often in areas of important tidal convergences.

In American waters, flocks of up to 600 were observed in Rosario Strait, in deeper waters of Bellingham Bay, Guemes Channel, off Ediz Hook, and off the south San Juan Channel. A major component of the dramatic movement was comprised of Brandt's Cormorants moving from roosts along the south shore of Lopez and in Rosario Strait to daytime foraging areas (Figure 27). The major regional foraging area for this species is in Active Pass, British Columbia (Vermeer 1977). Very large numbers fed in the strong tidal convergences and roosted during the day on adjacent shoreline rocks. Numbers observed were extremely variable, presumably dependent on tidal stage. Our maximum number observed in Active Pass was about 3,600 in late winter of 1978.

Nonbreeding birds remain in the study area through the summer after adults have departed, presumably to nesting colonies, as far south as the Farallon Islands, off San Francisco (Ainley in Vermeer 1977). Nonbreeders appeared to concentrate at night on Whale and Mummy Rocks, San Juan Channel.

c. Pelagic Cormorant. The Pelagic Cormorant nests in several locations in the study area (Figure 10). Major nest sites were Tatoosh Island, Protection Island, Smith Island, Colville Island, Viti Rocks, Bare Island, and Williamson Rocks (Table 3). It was seldom observed in flocks away from colonies or roosts, though a group of birds may congregate in feeding situations. Pelagic Cormorants apparently prefer to forage along a variety of shorelines and bays, and to some extent in tidal convergences, and they were a characteristic species of the kelp communities along many shorelines within the study area. As was the case with the Double-crested Cormorant, this species was observed only infrequently and then only in very small numbers in Active Pass, British Columbia, even though large numbers of Brandt's Cormorants were present.

4. Great Blue Heron

The Great Blue Heron is Blue Listed for North America as a species of widespread concern. It was a widely distributed, locally common species in the study area, and it was observed in a wide range of habitats from kelp beds to rocky shores and gull colony rocks to shallow estuaries with extensive intertidal exposure where the largest concentrations were observed. It is not strictly a marine species, though relatively large numbers use marine habitats. It roosts in trees along shore and on log booms.

In addition to general food-web concerns, problems faced by the species in the study area include threats of conversion of alder-stand nesting colony sites into housing developments. Several nesting locations have been documented near foraging grounds where larger counts of birds are recorded. One such location was at Padilla and Samish Bays and the well-known rookery on Samish Island. From incidental observations during censusing it appeared likely that many small rookeries are located generally near preferred estuaries and other foraging sites. Conversations with residents in addition to flight observations suggest a rookery of about 100 nests near the mouth of the Nooksack River. In addition, there may be relatively large undiscovered rookeries within the study area. Our censuses of Great Blue Herons were not as thorough as for other strictly marine species, nor were nesting rookeries or roosts sought out.

Census numbers can vary considerably due to stage of tide. Numbers of Great Blue Herons apparently decrease during the winter, but birds are present during all seasons. High counts of Great Blue Herons at the most heavily-used locations were: Birch Bay 75, Bellingham Bay 47, Portage Bay 40, Drayton Harbor 224, Lummi Bay 140, Samish Bay 304, Padilla Bay 317, Fidalgo Bay 60, Jamestown 24, Dungeness Spit 40, and Sequim Bay 32. High counts occurred in shallow water habitats and illustrate the need for preservation of these types.

5. Black Brant

This small marine goose is a species of widespread concern due to its vulnerability on wintering grounds, loss of historically important wintering areas in California and Mexico, hunting while wintering in Mexico, and uncertainties about its reproductive success in far northern nesting grounds (Einarsen 1965). It is also a game species, and management of harvest by humans, both through sport hunting and subsistence take by indigenous populations in the Arctic, is critical. Pacific flyway Black Brant populations decreased significantly during 1979-1980 (R. Parker pers. com.).

Black Brant in this area appeared dependent on eelgrass (Zostera marina). The Black Brant is perhaps the most easily disturbed of all species studied since it was easily flushed by small vessels and low-flying aircraft.

There are yearly population variations within the study area (Figure 22), and the species' presence, even during peaks of spring migration, is not consistent in some embayments. Portage Bay, near Bellingham, for example, has had large spring numbers in the past, but none were observed there during 1978-1979 censuses.

Sizeable over-wintering flocks of a few hundred or more were observed in Lummi Bay and Dungeness Bay, and to about 7,000 in Padilla Bay. Spring migration resulted in larger numbers of birds dispersed in virtually all eelgrass habitats in bays and along shorelines. The maximum spring populations at Padilla and Samish Bays, in particular, represented a significant proportion of the species' total population. Our averaged-estimates for spring 1978 were about 24,000 for Padilla Bay and 17,000 for Samish Bay, though numbers present at peak times in Padilla Bay ranged as high as 50,000. Other peak census counts during 1978 and 1979 were: Drayton Harbor 3,900, Birch Bay 2,000, Lummi Bay 4,000, Fidalgo Bay 2,200, Jamestown 1,600, Dungeness Spit 2,600, Dungeness Bay 4,000, and Low Point Area 1,400.

Padilla Bay represents a very important wintering-spring migration habitat for this species. However, it should be pointed out that there is potential habitat loss due to land-fill for industrial purposes or dredge-spoil disposal. There are two oil refineries with attendant tanker traffic adjacent to the area, and birds suffered disturbance from intense boat traffic alongside their primary preening/roost/graveling area on dredge-spoil gravel bars at the Swinomish Slough, as well as possible pressure from hunting from floating blinds.

Drayton Harbor, representing one of the important smaller habitats, has a number of marina development projects proposed for it which would eliminate habitat or introduce new magnitudes of disturbance by vessels into presently undisturbed eelgrass habitat. There is a marina proposed for Sequim Bay--another shallow eelgrass habitat.

Large numbers of Black Brant occur immediately outside the study area in Boundary Bay and at Roberts Bank, British Columbia. Virtually none appear to occur in the Skagit Delta area.

6. American Wigeon

The American Wigeon is widespread throughout North America (A.O.U. 1957). It is included because it tended to concentrate in very large numbers in a few localities in the study area. It was a fall-through-winter visitor, with none recorded in censuses in 1979 between 15 May and 29 August. More vegetarian than some other dabbling ducks (Kortright 1953), wigeon move inland from salt water embayments to graze in fields and marshes, especially at night during the hunting season. After hunting season ends they do so during daylight hours and so our day-time censuses made then may drastically understate numbers using marine habitats. Maximum counts of wigeon in locations where more than 1,000 were observed are: Drayton Harbor 4,500, Birch Bay 2,300, Lummi Bay 6,400, Jamestown 10,000, Sequim Bay 1,300, Dungeness Bay 9,600, and Dungeness Spit 4,600. Our maximum sample counts for Samish Bay were 4,100, and for Padilla Bay, 6,500. These latter two shore samples represented only a portion of wigeon habitat in these subregions and large numbers of unidentified dabbling ducks and duck sp. were also recorded. Actual peak numbers using these bays were probably several times these figures. Washington Dept. of Game long-term average figures for seasonal peaks were 50,000 dabbling ducks in Samish-Padilla-Fidalgo Bays and many of these were wigeon (R. Jeffrey, pers. comm.).

Figure 23 shows seasonal counts of American Wigeon at Drayton Harbor and Dungeness in 1978-1979. While stage of tide and weather may influence both numbers present and numbers observed, the low counts in early 1979 appear to represent post-hunting movements into fields. There was an influx in early spring and again in fall reaching a peak in November-December. (Note: Number of European Wigeon reported in the study area, particularly the Samish-Padilla Bays area, indicate a likely larger population wintering here [and in Fraser River Delta area] than in other parts of North America. Based on numbers of males observed in American Wigeon flocks, various observers [N. Lavers, P. deBruyn, J. Fackler, T. Wahl, pers. comms.] have estimated up to 5% of some wigeon flocks in the Samish Flats are composed of European Wigeon).

7. Harlequin Duck

This small diving duck was found along rocky shores and reefs in the study area during much of the year. The species is particularly vulnerable to oiling during this flightless season. The largest known Harlequin moulting area in the study area was at Protection Island, where 171 birds were observed during one census. Other observers have reported similar concentrations during this season (A. & A. Benedict, pers. comm.). Based on mid-summer censuses, other moulting sites appear to be Smith Island (Manuwal, pers. obs.), Cherry Point, Birch Point-Semiahmoo Spit, Waldron Island, Mosquito Pass, Boulder Reef (off Sinclair Island), Parker Reef, and Dungeness Spit.

The highest single census was 205 Harlequins at Point Whitehorn in April 1978. These birds were associated with a flock of 25,000 scoters, Oldsquaws, and other species feeding on herring spawn. Shoreline censuses from Cherry Point to Point Whitehorn and from Birch Point to Semiahmoo Spit consistently had from 24 to 34 Harlequins. However, this species was one of the least easily observed from the air and numbers observed on aerial censuses here and at other locations significantly understate numbers actually present.

Wintering flocks of 10-100 Harlequins were observed in many locations, including Point Roberts, Birch Bay, Cherry Point, South Bellingham, Chuckanut

Bay, Samish Bay, several Whidbey Island locations, Dungeness Spit, Quimper Peninsula, Sequim Bay, Voice of America, Port Angeles, Crescent Bay, and Clallam Bay. Flocks of 30-40 were observed at many locations throughout the San Juan Islands, with concentrations around reefs where the birds forage in intertidal areas.

8. Scoters

The three scoter species form a large component of the diving duck population of the study area. Scoters are widespread in distribution although largest concentrations were consistently found in regions along the eastern boundary of the study area: Anacortes-Hales Passage Bays, Georgia Strait-Eastern bays and shorelines, and in Dungeness and Voice of America areas. Flocks totalling hundreds of birds winter in bays and passages within the San Juan Islands. Table K-4 gives regional projected totals of scoters by region for winter and spring. Concentrations of nonbreeders spent mid-summer in several important locations: Boundary Bay, Drayton Harbor, Cherry Point, Bellingham Bay, Padilla Bay, Dungeness Bay, and Voice of America. Another similarly important area was at Penn Cove, Whidbey Island, just outside the study area.

Table K-4. Projected total numbers of scoters by region, winter 1978-1979 and spring 1979.

Region	Projected Total			
	Winter	%	Spring	%
Strait of Juan de Fuca-Outer	1,700	4	1,400	3
Strait of Juan de Fuca-Inner	8,700	19	8,300	16
Admiralty Inlet	100	+	100	+
Anacortes-Hales Passage	6,000	17	8,500	16
Georgia Strait-Eastern	21,000	45	25,000	47
Georgia Strait-Western	2,000	6	7,300	14
Haro Strait	200	+	400	1
Rosario Strait	400	1	200	+
San Juans-Northern Waters	30	+	30	+
San Juans-Interior Channels and Passages	600	1	20	+
San Juans-Interior Bays	5,200	11	1,800	3
Total	46,000		53,000	

+ = present, less than 1%

Late winter-spring populations of scoters were associated with herring spawning activity in Discovery Bay and particularly in Georgia Strait-Eastern, (Table K-5 and Section V-E). Our data suggest seasonal shifts in relative distribution of scoters during this season, and concentrations within subregions where spawn takes place.

Table K-5. Distribution of scoters and herring spawn by subregions in Georgia Strait region, spring 1979.

Subregion	Scoters[1]		Herring Spawn[2] (tons)	
		%		%
Hales Passage	2,700	11	1,200	15
Lummi Bay	1,400	6	+	+[3]
Cherry Point	10,500	43	4,700	57
Birch Bay	1,300	5	-[4]	-
Birch Point-Semiahmoo	5,000	20	1,500	19
Drayton Harbor	600	12	-	-
Point Roberts	2,900	12	800	10
Totals	24,400		8,100	

[1] Projected numbers.

[2] Source: Washington Dept. of Fisheries data.

[3] + = present, less than 1%.

[4] - = no data.

Scoters are vulnerable to impacts of oil spills. They spend their entire nonbreeding lives in marine waters: they dive for food and they congregate in flocks. In Europe, diving ducks, particularly scoters, made up the largest percent of birds killed in oil spills (Joensen 1972).

a. *White-winged Scoter*. This was the second most abundant scoter in the study area. This species was a winter resident, but populations of nonbreeding males remained in the study area during the summer. Most birds arrived in September, and the breeders left in April. While in Washington they spent 100% of their time on the water. Their food consisted primarily of little neck clams (*Venerupis staminea*), soft shell clams (*Macoma inguinata*), and small univalves. Their diving habits and behavior make them vulnerable to oil contamination. White-winged Scoters apparently have a somewhat more localized distribution than Surf Scoters, but they winter in many areas. While in some locations White-winged Scoters preferred shallower habitats than Surf Scoters (as at Birch Bay), flocks were also consistently found in deep water areas (Discovery Bay, Harney Channel). Censuses of 400 or more birds were obtained at Drayton Harbor, Birch Bay, Point Whitehorn, Samish Bay, Harney Channel, Discovery Bay, and Sequim Bay. Flocks ranging from 200-400 individuals were observed at Tsawwassen Bay, Semiahmoo Spit, Cherry Point, Lummi Bay, Padilla Bay, East Sound, Griffin Bay, Dungeness Bay, and Jamestown. The largest census totals were 2,300 at Discovery Bay and 2,500 at Point Whitehorn; both were associated with herring spawn.

b. Surf Scoter. Surf Scoter were common to abundant and widespread in distribution. Flocks were found in deeper waters of most bays within the study area, and along many open shorelines as well. Surf Scoters made up the great majority of the large scoter flocks foraging on herring spawn, outnumbering White-winged Scoters at Cherry Point by about 10:1. High census counts of Surf Scoters included four observations of 20,000-22,000 between Sandy Point and Point Whitehorn in the spring of 1978, and 16,000 during a census along the same shoreline at Cherry Point in spring 1979. All shorelines and bays around the Georgia Strait-Eastern perimeter from Point Roberts to Hales Passage had sizeable wintering flocks. Censuses of up to 500 birds were recorded in virtually all areas from Bellingham Bay to south Whidbey Island and along the Olympic Peninsula to Voice of America, at Neah Bay, and in the San Juan Islands, particularly at Mosquito Pass/Roche Harbor, and Lopez Sound.

c. Black Scoter. This scoter was common only locally. Flocks of 50 to 100 birds were consistent both winters at Semiahmoo Spit, Drayton Harbor, Birch Point, Birch Bay, and Hales Passage. The largest groups seen outside the herring spawn season in both winters was 160-240 seen at Lummi Bay. Herring spawn attracted 500 to Point Whitehorn in April 1978. Thirty seen at Voice of America in 1979 was the largest number censused on the Olympic Peninsula.

9. Common Murre

While Common Murres nested only at Tatoosh Island at the western edge of the study area (Figure 14), this species represented a significant portion of the wintering seabird population in Washington's inside waters and was certainly the most abundant species of the family Alcidae at that season.

Table K-6 shows mean seasonal projected totals (1978 and 1979 combined) by regions. This depicts the movement of murres into the Strait of Juan de Fuca and Haro Strait, with numbers then decreasing there and increasing in regions farther from the ocean. Lower total numbers in winter than in fall likely reflect movement of some birds through the study area into Puget Sound or Canadian waters to the north. Note the numbers in both Georgia Strait regions in spring 1979--this is the season of herring spawn in these regions. Figure 28 depicts the monthly projected totals of Common Murres in Regions 2 and 3 in 1978, illustrating the movement of birds into and out of the regions.

Birds are observed moving north along the Washington coast during post-breeding dispersal (Speich, pers. obs.) and there is reason to believe birds

Table K-6. Seasonal projected totals of Common Murres by region the study area, 1978 and 1979, averaged.

Region	Spring	Summer	Fall	Winter
Western Strait of Juan de Fuca	1,400	1,200	110,000	26,000
Eastern Strait of Juan de Fuca	1,100	1,300	24,000	12,000
Admiralty Inlet	40	2	450	1,200
Anacortes-Hales Pass	330	40	9,200	5,800
Georgia Strait-Eastern	7,400	460	9,000	17,000
Georgia Strait-Western	1,300	20	70	710
Haro Strait	170	10	7,100	1,600
Rosario Strait	610	3	11,000	11,000
Northern Waters	20	--	1,700	5,300
San Juan's Passages	50	40	940	2,700
San Juan's Bays	10	4	330	200
Canadian Waters	70	1	280	2,500

from as far south as the Farallon Islands may winter in the study area (Jewett et al. 1953). It is also possible, however, that birds from northern waters, including Alaska, may also winter here (observation of one Thick-billed Murre in San Juan Channel and two more near Ocean Shores in late 1979, plus regular wintering presence of the Ancient Murrelet, another alcid nesting to the north, are indications of this possibility).

Common Murres were primarily found in deeper water within the study area, and hence in offshore components of subregions. Largest numbers recorded on censuses were observed in the Strait of Juan de Fuca, Rosario Strait, Haro Strait, Georgia Strait, Admiralty Inlet, in deep channels of the San Juan Islands and off the shore of Lopez Island and Deception Pass. Most Murres probably spent the night in offshore waters of the Strait of Juan de Fuca, since large numbers were regularly observed flying north past Green Point in early morning and landing to forage in tidal convergences in Rosario Strait.

Because of its large numbers and life history characteristics the Common Murre is one of the most vulnerable species to oil spills in the study area (Appendix B). Murres are also among the species most frequently caught in fish nets in the northern hemisphere (Tull et al. 1972; Pacific Seabird Group 1975; Manuwal 1978).

10. Marbled Murrelet

This small alcid was relatively common in the study area, though concentrations were seen rather locally in foraging areas such as nearshore tidal convergences. In addition to being a member of the vulnerable family Alcidae, the status of this species is noteworthy in that no nest has yet been found in Washington State despite its summer abundance. This has implications for assessments of oil transportation and coastal land-use decisions. Very few Marbled Murrelet nests have been found anywhere over its northeastern Pacific range. A nest was found in the top of a tall conifer in Northern California (Binford et al. 1975), two nests were found on open hillsides in the Barren Islands, Alaska (Simons 1980), and in larch trees in Siberia (see Binford et al. 1975). There are undocumented reports for Washington (see Jewett et al. 1953) and British Columbia.

This species was often locally concentrated, especially during the nesting season. While it has been suggested Marbled Murrelets nest inland in mountain forests or talus slopes (Jewett et al. 1953), some observations during the MESA study suggest concentrations near possible nest sites. These included sightings (usually of pairs) of 50 or more during censuses off Green Point near Anacortes, in Hughes-McCardle-Aleck Bays, Wasp Pass, Lopez Sound, and off the west sides of Lummi and Cypress islands. Concentrations during other seasons were at these locations and also at Bellingham Bay, Hales Passage, Point Roberts, Samish Bay, Obstruction Pass, Guemes Channel, and Voice of America. Single census concentrations of 199 at South Bellingham, 287 in Hales Passage, 235 at Voice of America and 177 in Obstruction Pass were noteworthy. This species apparently concentrated in the study area in larger numbers as is indicated by 5,200 Marbled Murrelets observed passing south off Point Roberts at first light in January 1978. This also suggests especially high vulnerability in such circumstances. The species is one of the least conspicuous from the air, and our seasonal estimates are likely conservative.

11. Rhinoceros Auklet

This species represented about 60% of all marine birds nesting in the study area (Table 5), although it nested only at Protection Island, Smith Island, and Tatoosh Island. It comprised a large proportion of all marine birds present in the study area from late spring through early fall. Rhinoceros Auklets often occur in large numbers in localized feeding areas. They are highly vulnerable to oiling and habitat loss. The Washington population of this species is an important part of the known northeastern Pacific population (Manuwal and Campbell, 1979).

The species' very limited nesting distribution (Figure 19) and localized foraging distribution (Figures 24 and 26), especially during the nesting season in relation to existing shipping and oil transportation routes and proposed oil port and pipeline facilities, prompted us to try to specifically outline its distribution during the critical period when adults are feeding young in the nest. This survey showed that Rhinoceros Auklets were essentially found within the Strait of Juan de Fuca east of a line from Port Angeles to Victoria, in San Juan Channel north to Friday Harbor, in Upright Channel, Rosario Strait north to Anacortes, and particularly in northern Admiralty Inlet, where an estimated one-third of the total breeding population was foraging in mid-day. Other concentrations were between Smith Island and the

Whidbey Island shoreline, over Salmon Bank off San Juan Island, San Juan Channel, offshore from Voice of America, and over offshore Hein and Partridge Banks (Figure 26). Large numbers were observed during individual censuses in these foraging areas. Highest counts were during sea watches when, for example, 3,800/hr passed Point Wilson on return flights from foraging areas (Figure 25). After the young left the colonies, the foraging range appeared to expand somewhat, although the main part of the population remained in the Strait of Juan de Fuca-Inner, Rosario Strait, San Juan, and Upright channels, and Admiralty Inlet. Some birds moved south of Admiralty Inlet into Puget Sound and perhaps into Hood Canal) but comparative densities are unknown there. A relatively small percentage of the population remained in winter, when most of the population apparently migrates south along Pacific Coast from southern Oregon to southern California. The only winter concentrations appear to be in the southern Puget Sound where a few hundred birds appear to forage on herring schools (Wash. Dept. of Fish, pers. comm.). U. Wilson (pers. comm.) observed flightless adults both in southern Puget Sound and in waters east of Protection Island during fall. Our censuses showed small numbers of Rhinoceros Auklets were present in the study area in winter, with a few birds scattered through the San Juan Island passages and often a small flock in Friday Harbor.

In addition to threats of oil impacts shared in common with other species of diving birds, this species faces serious impacts on its Protection Island nesting colony, where 97% of the study area population nests (Table 5). Destruction of the colony due to possible housing development, and virtually inevitable introduction of man-associated predators are two major threats, along with other impacts such as food-web perturbations and high vulnerability when large numbers of moulting birds are flightless.

B. Additional Species

a. Red-necked Grebe. This species, designated as Blue List, Class I, was a relatively widespread winter visitor within the study area. Concentrations of 50-100 were observed in many shallow estuaries and tidal channels: in Admiralty Inlet, Bellingham Bay, Drayton Harbor, Hale Passage, Padilla Bay, Samish Bay, and Lopez Sound. Though the species seldom occurred in tight flocks, concentrations of 300-400 were noted in Sequim Bay and Voice of America subregions (Wahl observed 600 off Green Point, Voice of America subregion before this study). Our study area supports an important, apparently stable part of the North American population of this species and, like other divers, it is quite vulnerable to oil spills.

b. Eared Grebe. This small grebe is classed as Blue List, Class III. It occurred sporadically in very small numbers in many bays and other habitats frequented by grebes in the study area. It was a migrant and scarce winter visitor. It generally prefers relatively shallow waters. The only relatively consistent population near the study area appeared to be an annual wintering flock of 50-100 in Penn Cove, on the east side of Whidbey Island.

c. Whistling Swan. Now a relatively abundant species over North America, the Whistling Swan has a very local distribution in the study area. Small migrating groups were observed in several locations in the San Juan Islands, Drayton Harbor, Lummi Bay, Voice of America, and Neah Bay areas. The only wintering area was at the Nooksack Delta, on the north end of Bellingham Bay, where 61 birds were the maximum censused in 1979. This and two other flocks in the general region (50± at Roberts Bank, British Columbia; and 300± at the Skagit River Delta, Skagit County) accounted for almost all of the known wintering population of the species for the inland waters area. There was some interchange between flocks, at least between the Nooksack and Skagit areas. Since Whistling Swan distribution is clumped, the species is especially vulnerable to habitat loss or damage.

d. Trumpeter Swan. Listed as Blue List, Class II, this species winters in very significant numbers in fresh water habitats adjacent to the eastern perimeter of the study area. The largest flock, 300+ birds, wintered near Clear Lake, Skagit County; smaller groups now winter in inland Whatcom County lakes near Lynden and Sumas. This range will likely expand as the species' population recovers from its endangered levels of the 1930s. Small groups and individuals were observed in marine areas during migration and when severe winter weather froze inland fresh water, especially in Whatcom County. Three birds were observed with Whistling Swans at Bellingham Bay in 1979, and in addition there have been sightings of adults and immatures at Lummi Bay, northwest of Bellingham, and in Clallam County. The main Skagit County wintering area is threatened by development. The dispersal of this population may increase species' occurrence in the marine ecosystem.

e. Snow Goose. While observed only infrequently within the study area itself, Snow Geese winter on the Skagit Delta and pass through the study area during migration to and from the Siberian Arctic, and flocks frequently interchange between the Skagit River Delta and the Fraser River Delta, British Columbia. The species is very localized in winter, and suffers from extreme "boom and bust" swings of population cycles (7,000-26,000 range in the Skagit flock), apparently due to marginal nesting conditions in the Arctic. It is thus extremely vulnerable to habitat loss or damage either through development or oil spills. An impact during a low point on the population cycle when virtually all birds are the next season's potential breeding adults could be disasterous.

f. Canvasback. The distribution of this diving duck in the study area was extremely limited. The only consistent wintering flocks in 1979 were about 25 in Birch Bay, 350 in Drayton Harbor, 280 in Padilla Bay, and 60 in Samish Bay. A perennial concern to game management agencies due to varying reproductive conditions in inland North America, this species is locally vulnerable in the study area.

g. Ruddy Duck. This small diving duck winters very locally in the study area. The only flocks of 100 or more birds observed in 1979 were maximum counts of 2,300 at Drayton Harbor, 300 at Birch Bay and 700 at Fidalgo Bay. A flock of 35 at Sequim Bay was the only concentration observed in the Olympic Peninsula part of the study area.

h. Hooded Merganser. This Blue-Listed, Class III species is widespread in small numbers in the study area during the winter. It was usually found in relatively protected waters, among log booms and along shorelines. Ten or more birds during a census were observed only in Bellingham Bay, Port Angeles, Friday Harbor, Wasp Pass, Sequim Bay, Chuckanut Bay, Lopez Sound, and Mosquito Pass/Roche Harbor area.

i. Bald Eagle. While it is a species of concern ("threatened") over much of North America, the Bald Eagle is relatively common over much of the study area. We did not intensively search for this species, but we observed many birds along the shoreline. To possibly supplement data compiled by others (Grubb et al. 1976) regarding nest sites and San Juan Islands and inland winter distribution especially along the Nooksack and Skagit Rivers (Servheen 1975), we include the Bald Eagle in this report.

Maximum numbers of more than 10 birds/census were observed only at Matia Island, Skipjack Island area, Padilla Bay, Active Pass, and Bellingham Bay where a high count in late winter-early spring of 19 included 15 immatures at Nooksack Delta (other counts of 11, 11 and 13 were made there). We consistently observed birds on seabird rocks (Bird Rocks, Peapods for example) and along much of the shorelines of the San Juan Islands as well as the Canadian Gulf Island and mainland shorelines particularly in the Anacortes-Hales the study area is 260.

j. Peregrine Falcon. The eastern part of the study area includes one of the most important wintering areas for Peregrines in populated North America. Until recently, all these birds were considered to be Peale's Falcon, *Falco peregrinus pealei*, the subspecies residing along the British Columbia coast. It is now evident that at least some of the wintering Peregrines in the area are *F. p. anatum*, the endangered subspecies (C.M. Anderson, pers. comm.). Since Peregrines are linked to marine food webs, feeding on ducks, shorebirds and alcids in the study area, we stress that habitat protection is essential. Further, Peregrines historically nested within the study area and do so now in the Gulf Islands, British Columbia. If nesting within the study area is documented, immediate protection of the nest site and study of the situation relative to disturbance, food webs, and pollution sources is imperative. Like Bald Eagles, Peregrine Falcons are more numerous than our eight incidental sightings indicate. Single birds were observed at Jamestown, Sucia Island, Bellingham Bay and Cattle Point; and twice each at Dungeness Spit and Padilla Bay. Padilla and Samish Bays in particular have several wintering birds each year.

k. Gyrfalcon. The Gyrfalcon is often sympatric with the Peregrine in Washington. It is rare in populated North America and is irregularly noted in delta-estuarine areas like Lummi Bay, Samish Bay, Padilla Bay, and Skagit Bay. We noted one bird at Green Point, west of Anacortes, in November 1979.

l. Merlin. Merlins were only infrequently observed during censuses but are relatively regular in small numbers particularly in river delta areas where they often prey on shorebirds, especially Dunlins. We had six sightings during censuses in addition to incidental observations while we traveled between census locations.

m. Black Oystercatcher. This locally-distributed nesting species (see Table 5 and Figure 12) occurs in limited suitable habitat, chiefly on offshore rocks and small islands. Because of its small total population and vulnerability to damage of its specialized, rocky intertidal habitat, we list locations and sizes of wintering flocks observed. Crescent Bay 56, Green Point (Anacortes) 16, Protection Island 35, Black Rock (Rosario Strait) 12, Harbor Rock (San Juan Channel) 14, Mummy Rocks 41, Peapods 12, Rock south of Turn Island (San Juan Channel) 24, Sequim Bay 10, and Mandarte Island 20.

n. Shorebirds. The families Charadridae and Scolopacidae are represented by several species in the study area. We briefly discuss them because of habitat considerations.

A small number of Surfbirds, Black Turnstones, and Rock Sandpipers winter on the geographically-limited rocks, reefs, jetties, and rocky shorelines of the area. Many of these locations are probably secure from alteration because of their exposed nature or seasonal inaccessibility to human use. Log-booms (at Port Angeles and Bellingham) have provided roosts and supplemental foraging habitat. This habitat is being reduced at Bellingham and numbers of Black Turnstones observed there have also declined in recent years. As in the case of Black Oystercatchers, all foraging habitat used by these specialized feeders is vulnerable to contamination by oil.

The remainder of the shorebird species recorded in the area have somewhat wider range of foraging surfaces, occurring in saltmarsh, intertidal sand and mud habitats and fields at certain seasons. Their marine habitats are vulnerable not only to oiling and other contamination of habitats and food, but also to human developments which alter estuarine habitats. Suitable foraging habitat for this group of birds has been reduced in the study area due to dredge-and-fill type operations and is now relatively limited. Some areas were partially inaccessible for censusing, and data for this group are relatively limited and irregular in scope. However, important habitats within the study area include Dungeness Bay, Sequim Bay, False Bay (San Juan Island), Fisherman Bay (Lopez Island), Crockett's Lake (Whidbey Island), Fidalgo Bay, Padilla Bay, Samish Bay, Nooksack Delta, Lummi Bay, Birch Bay, and Drayton Harbor. Boundary Bay and the Fraser River foreshore in British Columbia are also very important shorebird locations, as are Skagit and Port Susan Bays which are adjacent the study area, east of Whidbey Island.

These habitats are important for migrating and wintering populations and there is a continuing need for protection. Populations of shorebirds, along with waterfowl and Peregrine Falcons, are dependent upon these fragile estuarine areas. Species recorded in the study area are noted in Appendix C.

o. Common Tern. The Common Tern is a locally common to abundant migrant in western Washington. It is Blue Listed, Class I, by National Audubon Society (Arbib 1979). It was observed most often foraging in tidal convergences throughout the study area, and was often observed resting on adjacent shorelines and floating kelp and drift logs. It also foraged to some extent in bays and estuaries and roosts on exposed tide flats, beaches and log booms. In view of its North American designation as a species of concern, its abundance within the study area probably reflects the biological health of the ecosystem. Significant numbers of this species were observed at: Birch Bay 80, Drayton Harbor 360, Port Angeles 1,000, Dungeness Bay 360, Point Roberts 130, Portage Bay 113, Speiden Channel 480, south shore of San Juan Island 530, Thatcher Pass 160, Rosario Strait 90, Cattle Point 450, Sequim Bay 350, Friday Harbor 510, Roche Harbor/Mosquito Pass 160, Clallam Bay 180, and Crescent Bay 180. The species occurred at many other locations in flocks of up to 100. There is evidence, because of mid-June observations, that Drayton Harbor is an important location for nonbreeding birds in summer.

p. Caspian Tern. This species ranges nearly worldwide (A.O.U., 1957), but occurs only in small numbers within the study area. Large nesting colonies have been established at Willapa Bay and Grays Harbor on the Washington coast (Peters et al. 1978), and small numbers were observed each summer and early fall along the Strait of Juan de Fuca and in inland waters. We recorded a total of 15 sightings in 1978 and 20 in 1979. Most were of singles or small groups of birds. However, a flock of up to 24 birds was observed in summer 1979 roosting on dredged material islands along the Swinomish Slough and fishing over Padilla Bay. This location, site of a Glaucous-winged Gull colony, is the most likely, and perhaps the only, potential site where this species may attempt to nest in study area. This location is potentially subject to alteration by channel dredging which could affect nesting possibilities.

q. Ancient Murrelet. Ancient Murrelets nest, if at all, in only very small numbers along the outer coast of Washington (Speich, pers. obs.), but the study area represents important wintering range for this small North Pacific alcid. It was present in largest numbers from about early November through early January, though we recorded numbers until late winter in Georgia Strait, when large numbers were also reported in the Strait of Juan de Fuca near Victoria (S. Sealy, pers. comm.).

Ancient Murrelets usually occurred in small groups of up to 25-30 birds, concentrated in deeper channels and tidal convergences. These concentrations frequently occurred in the Strait of Juan de Fuca, Haro Strait, Rosario Strait, Georgia Strait, Admiralty Inlet, San Juan Channel, and peripheral nearshore areas like Port Angeles and along the south shore of Lopez Island. Large early-winter feeding flocks of Arctic Loons, cormorants, gulls, and Common Murres often included groups of Ancient Murrelets.

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